

**IN THE UNITED STATES DISTRICT COURT  
FOR THE EASTERN DISTRICT OF TEXAS  
SHERMAN DIVISION**

AMERICAN PATENTS LLC,

Plaintiff,

v.

MOTOROLA SOLUTIONS, INC.,

Defendant.

CIVIL ACTION NO. 4:21-cv-856

ORIGINAL COMPLAINT FOR  
PATENT INFRINGEMENT

**JURY TRIAL DEMANDED**

**ORIGINAL COMPLAINT FOR PATENT INFRINGEMENT**

Plaintiff American Patents LLC (“American Patents” or “Plaintiff”) files this original complaint against Defendant Motorola Solutions, Inc. (“Motorola Solutions”), alleging, based on its own knowledge as to itself and its own actions and based on information and belief as to all other matters, as follows:

**PARTIES**

1. American Patents is a limited liability company formed under the laws of the State of Texas, with its principal place of business at 2325 Oak Alley, Tyler, Texas, 75703.

2. Motorola Solutions, Inc. is a corporation duly organized and existing under the laws of Delaware. Motorola Solutions, Inc. may be served through its registered agent CT Corporation System at 1999 Bryan Street, Suite 900, Dallas, Texas 75201.

3. Motorola Solutions, Inc. and its foreign and United States subsidiaries, affiliates, and related companies (“Motorola Solutions and its affiliates”) comprise one of the world’s largest manufacturers of communications and telecommunications equipment and devices, including under the Motorola Solutions brand.

4. Motorola Solutions and its affiliates are part of the same corporate structure and distribution chain for the making, importing, offering to sell, selling, and using of the accused devices in the United States, including in the State of Texas generally and this judicial district in particular.

5. Motorola Solutions and its affiliates share the same management, common ownership, advertising platforms, facilities, distribution chains and platforms, and accused product lines and products involving related technologies.

6. Motorola Solutions and its affiliates regularly contract with customers regarding equipment or services that will be provided by their affiliates on their behalf.

7. Thus, Motorola Solutions and its affiliates operate as a unitary business venture and are jointly and severally liable for the acts of patent infringement alleged herein.

#### **JURISDICTION AND VENUE**

8. This is an action for infringement of United States patents arising under 35 U.S.C. §§ 271, 281, and 284–85, among others. This Court has subject matter jurisdiction of the action under 28 U.S.C. § 1331 and § 1338(a).

9. This Court has personal jurisdiction over Motorola Solutions pursuant to due process and/or the Texas Long Arm Statute because, *inter alia*, (i) Motorola Solutions has done and continues to do business in Texas; (ii) Motorola Solutions has committed and continues to commit acts of patent infringement in the State of Texas, including making, using, offering to sell, and/or selling accused products in Texas, and/or importing accused products into Texas, including by Internet sales and sales via retail and wholesale stores, inducing others to commit acts of patent infringement in Texas, and/or committing a least a portion of any other infringements alleged herein; and (iii) Motorola Solutions is registered to do business in Texas.

10. Venue is proper in this district pursuant to 28 U.S.C. § 1400(b). Venue is further proper because Motorola Solutions has committed and continues to commit acts of patent infringement in this district, including making, using, offering to sell, and/or selling accused products in this district, and/or importing accused products into this district, including by Internet sales and sales via retail and wholesale stores, inducing others to commit acts of patent infringement in Texas, and/or committing at least a portion of any other infringements alleged herein in this district. Motorola Solutions has regular and established places of business in this district, including at least at 415 E. Exchange Parkway, Allen, Texas 75002:

The screenshot shows the Collin Central Appraisal District website. At the top, there is a header with the district's name and a map of the area. Below the header is a navigation bar with links to Home, Property Search, Maps, Downloads, Forms, and Reports. The main content area is titled "Property Search" and includes buttons for "New Search", "Revise Current Search", and "Export Results". A legend on the right side of the page identifies property types: Business Personal Property (red), Mineral (blue), Mobile Home (orange), and Real (green). The search results section, titled "Matching properties 2 properties", displays a table with two results:

	Property ID [ Geographic ID ]	Owner Name	Property Address	Legal Description	2021 Market Value
1	2598894 P-0000-208-2374-1	MOTOROLA SOLUTIONS INC	415 E Exchange Pkwy Allen, TX 75002	BPP at 415 E Exchange Pkwy	\$18,249,593
2	2729961 P-0000-215-3405-1	MOTOROLA SOLUTIONS VIDEO MANUFACTURING INC	2910 Telecom Pkwy Richardson, TX 75082	BPP at 4001 E Plano Pkwy	\$3,579,057

On the right side of the page, there is a "Site Navigation" menu with links to Home, Property Search, Maps, Downloads, Calendar, and Annual Reports. The "Property Search" link is highlighted.

(Source: Collin County Appraisal District website)



(Source: screenshot from Google Maps Street View)

### **BACKGROUND**

11. The patents-in-suit generally pertain to communications networks and other technology used in “smart” devices such as smartphones, smart TVs, and smart appliances. The technology disclosed by the patents was developed by personnel at Georgia Institute of Technology (“Georgia Tech”) and Nokia Corporation (“Nokia”).

12. Georgia Tech is a leading public research university located in Atlanta, Georgia. Founded in 1885, Georgia Tech is often ranked as one of the top ten public universities in the United States. The patents from Georgia Tech (“the Mody patents”) were developed by a professor and a graduate student in Georgia Tech’s Electrical and Computer Engineering department. The undergraduate and graduate programs of this department are often ranked in the top five of their respective categories.

13. The Mody patents are related to Multi-Input, Multi-Output (MIMO) technology. The inventors of the Mody patents were at the forefront of MIMO, developing, disclosing, and patenting a solution for achieving both time and frequency synchronization in MIMO systems.

The Mody patents (or the applications leading to them) have been cited during patent prosecution hundreds of times, by numerous leading companies in the computing and communications industries, including AMD, Alcatel Lucent, Altair, AT&T, Atheros, Blackberry, Broadcom, Comcast, Ericsson, Facebook, HP, Hitachi, Huawei, Infineon, Intel, Interdigital, IBM, Kyocera, Marvell, Matsushita, Mediatek, Motorola, NEC, Nokia, Nortel Networks, NXP, Panasonic, Philips, Qualcomm, Realtek, Samsung, Sanyo, Sharp, Sony, STMicroelectronics, Texas Instruments, and Toshiba.

14. Nokia is a Finnish multinational telecommunications, IT, and consumer electronics company. Listed on both the Helsinki Stock Exchange and the New York Stock Exchange, Nokia regularly makes the Fortune Global 500. Nokia has been the largest worldwide vendor of mobile phones and smartphones and has been a major contributor to the mobile phone industry.

15. The patent developed at Nokia (“the Rauhala patent”) is related to reduction of interference in receivers with multiple antennas. The inventors of the Rauhala patent have a combined fifty plus years of experience at Nokia and were prolific inventors for Nokia. Inventor Jyri Rauhala spent over 25 years at Nokia. Mr. Rauhala obtained a Master of Science in Applied Electronics, Digital Electronics from Tampere University of Technology in Finland and is named as an inventor on 15 U.S. patents. Inventor Olli-Pekka Lunden spent over 8 years at Nokia. Dr. Lunden obtained a Doctor of Science in Technology, Radio Engineering from Aalto University and is named as an inventor on 5 U.S. patents. Currently, Dr. Lunden works as a university lecturer at Tampere University of Technology in Finland. Inventor Marko Erkkila spent over twenty years at Nokia. Mr. Erkkila obtained a Master of Science in Digital Signal Processing,

Electronics, Computer Science from Tampere University of Technology in Finland and is named as an inventor on 6 U.S. patents.

**COUNT I**

**INFRINGEMENT OF U.S. PATENT NO. 7,088,782**

16. On August 8, 2006, United States Patent No. 7,088,782 (“the ‘782 Patent”) was duly and legally issued by the United States Patent and Trademark Office for an invention entitled “Time And Frequency Synchronization In Multi-Input, Multi-Output (MIMO) Systems.”

17. American Patents is the owner of the ‘782 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the ‘782 Patent against infringers, and to collect damages for all relevant times.

18. Motorola Solutions used products and/or systems including, for example, its Motorola Solutions APX NEXT All-Band P25 Smart Radio, Motorola Solutions APX NEXT XE All-Band P25 Smart Radio, and Motorola Solutions LEX L11 Mission Critical LTE Device families of products, that include LTE capabilities (“accused products”):

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APX NEXT™ All-Band P25 Smart Radio
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[TWO-WAY RADIOS](#) >
[PROJECT 25 RADIOS](#) >
[APX P25 PORTABLE RADIOS](#) >
[APX NEXT ALL-BAND P25 SMART RADIO](#)

## APX NEXT All-Band P25 Smart Radio

**Protect your focus when it matters most.**

Available in multi-band and single-band, APX NEXT advances usability and performance in every aspect of the radio. Accelerated workflows. Mission-critical reliability. All protecting the focus that keeps responders safe and effective.

HOW TO BUY

Experience APX NEXT

Body camera integration


Specifications

Get started






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(Source: [https://www.motorolasolutions.com/en\\_us/products/two-way-radios/project-25-radios/portable-radios/apx-next.html](https://www.motorolasolutions.com/en_us/products/two-way-radios/project-25-radios/portable-radios/apx-next.html))

7




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APX NEXT XE All-Band P25 Smart Radio

Product Details

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## APX NEXT XE All-Band P25 Smart Radio

**Focused in the extreme.**


Orderable in multi-band or single-band, APX NEXT XE merges glovable oversized controls with field intelligence for reliable use of your lifeline in extreme environments. Stay focused on your call, your firefighters, and your safety.


HOW TO BUY


Share



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 Tour APX NEXT XE

 Body camera integration



(Source: [https://www.motorolasolutions.com/en\\_us/products/two-way-radios/project-25-radios/portable-radios/apx-next-xe.html](https://www.motorolasolutions.com/en_us/products/two-way-radios/project-25-radios/portable-radios/apx-next-xe.html))





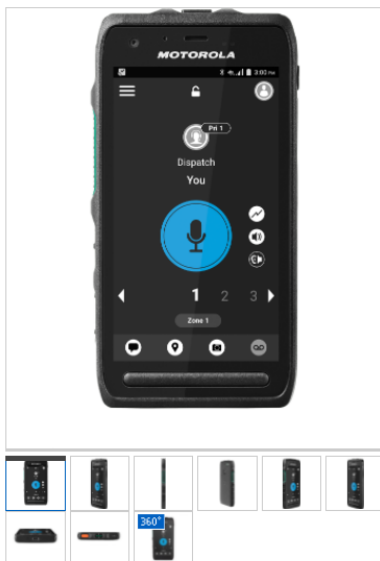
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# LEX L11 MISSION CRITICAL LTE DEVICE

## Made For The Mission Ahead



When hardware, software, and accessories work seamlessly together, the result is a device that works seamlessly for you.

The LEX L11 Mission Critical LTE Device is designed with first responders in mind. It's the result of our tireless quest to understand the way you actually work.

Every feature and function is thoughtfully considered, from the rugged, easy to operate design to the always loud and clear audio to the advanced end-to-end secure mobile platform and the enhanced accessibility provided by a suite of accessories.

Rugged and durable yet streamlined and slim, you can count on the LEX L11 to perform when it's needed most.

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[BROCHURE](#)
[LEX L11 COMPARISON TOOL](#)
[SPECIFICATIONS](#)
[HOW TO BUY](#)
[GET SUPPORT](#)
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(Source: [https://www.motorolasolutions.com/en\\_us/products/lte-user-devices/lexl11.html#tabproductinfo](https://www.motorolasolutions.com/en_us/products/lte-user-devices/lexl11.html#tabproductinfo))

### WIRELESS

#### LTE

Bands Supported 2, 4, 12, 13, 14

Bands (Hardware Ready) 5, 17

Device Category 4

Certifications FirstNet®, Verizon, Bell Mobility

#### WiFi

Standards Supported 802.11a/b/g/n/ac

Frequency Range 2400-2472, 5180-5825 MHz

Security Supports WPA-2, WPA, WEP

Capacity Up to 20 SSIDs

#### Bluetooth

Version 5.0

Frequency Range 2402 - 2480 MHz

Security 128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

<b>WIRELESS</b>	
<b>LTE</b>	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon®, Bell Mobility
<b>WiFi</b>	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
<b>Bluetooth</b>	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: [https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX\\_NEXT\\_XE\\_DS\\_FINAL.pdf](https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX_NEXT_XE_DS_FINAL.pdf))

<b>Wide Area Networks</b>	
Standards	FDD-LTE/TDD-LTE/GSM/UMTS/HSPA+
LTE release	Includes LTE 3GPP Release 11 features, Category 9 Capable

(Source: <https://fccid.io/AZ489FT7104/User-Manual/Users-Manual-Eng-rev2-pdf-3927178>)

User equipment Category	Max. L1 data rate Downlink (Mbit/s)	Max. number of DL MIMO layers	Max. L1 data rate Uplink (Mbit/s)	3GPP Release
NB-I	0.68	1	1.0	Rel 13
MI	1.0	1	1.0	
0	1.0	1	1.0	Rel 12
1	10.3	1	5.2	Rel 8
2	51.0	2	25.5	
3	102.0	2	51.0	
4	150.8	2	51.0	
5	299.6	4	75.4	
6	301.5	2 or 4	51.0	Rel 10
7	301.5	2 or 4	102.0	
8	2,998.6	8	1,497.8	
9	452.2	2 or 4	51.0	Rel 11
10	452.2	2 or 4	102.0	
11	603.0	2 or 4	51.0	
12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)

19. By doing so, Motorola Solutions has directly infringed (literally and/or under the doctrine of equivalents) at least Claim 30 of the ‘782 Patent. Motorola Solutions’s infringement in this regard is ongoing.

20. Motorola Solutions has infringed the ‘782 Patent by using the accused products and thereby practicing a method for synchronizing a Multi-Input Multi-Output (MIMO) Orthogonal Frequency Division Multiplexing (OFDM) system in time and frequency domains. For example, the accused products support the LTE standard and MIMO technology. According

to the LTE standards, the physical layer performs various functions which include modulation and demodulation of physical channels as well as time and frequency synchronization.

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
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(Source: [https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX\\_NEXT\\_XE\\_DS\\_FINAL.pdf](https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX_NEXT_XE_DS_FINAL.pdf))

**Wide Area Networks**

Standards	FDD-LTE/TDD-LTE/GSM/UMTS/HSPA+
LTE release	Includes LTE 3GPP Release 11 features, Category 9 Capable

(Source: <https://fccid.io/AZ489FT7104/User-Manual/Users-Manual-Eng-rev2-pdf-3927178>)

User equipment Category	Max. LI datarate Downlink (Mbit/s)	Max. number of DL MIMO layers	Max. LI datarate Uplink (Mbit/s)	3GPP Release
NB-I	0.68	1	1.0	Rel 13
MI	1.0	1	1.0	
0	1.0	1	1.0	Rel 12
1	10.3	1	5.2	Rel 8
2	51.0	2	25.5	
3	102.0	2	51.0	
4	150.8	2	51.0	
5	299.6	4	75.4	
6	301.5	2 or 4	51.0	Rel 10
7	301.5	2 or 4	102.0	
8	2,998.6	8	1,497.8	
9	452.2	2 or 4	51.0	Rel 11
10	452.2	2 or 4	102.0	
11	603.0	2 or 4	51.0	
12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)

## 5.2 Overview of L1 functions

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing
- Transmit Diversity (TX diversity)
- Beamforming
- RF processing.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.pdf](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf))

### Synchronization Signals (PSS and SSS)

In LTE, there are two downlink synchronization signals which are used by the UE to obtain the cell identity and frame timing.

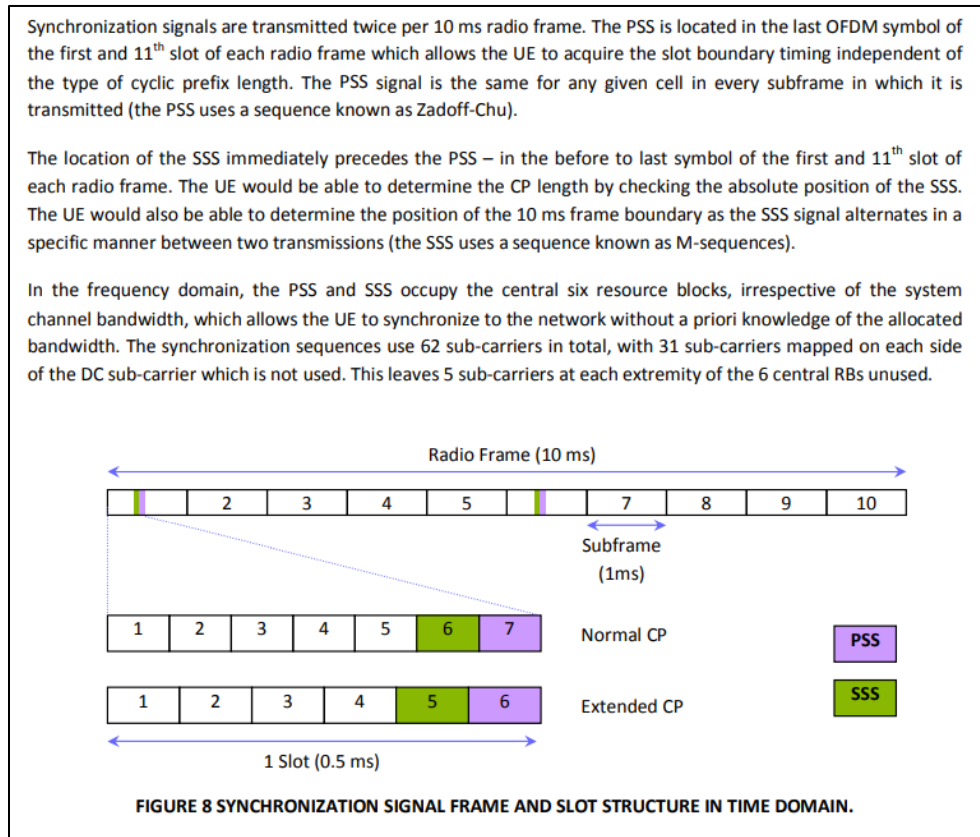
- Primary synchronization signal (PSS)
- Secondary synchronization signal (SSS)

The division into two signals is aimed to reduce the complexity of the cell search process.

(Source: <https://in.mathworks.com/help/lte/ug/synchronization-signals-pss-and-sss.html>)

21. The methods practiced by Motorola Solutions's use of the accused products include producing a frame of data comprising a training symbol that includes a synchronization component that aids in synchronization, a plurality of data symbols, and a plurality of cyclic prefixes. For example, the physical layer performs the modulation and demodulation of the

physical channels. Further, it uses OFDM in the downlink physical channel. Hence, there would be OFDM modulators present in transmitter of the apparatus (mobile devices such as the accused products) for modulating the data signals. The physical layer transmits downlink frames that include data symbols, pilot symbols such as PSS, SSS, reference symbols and cyclic prefixes for each symbol.



(Source: <https://home.zhaw.ch/kunr/NTM1/literatur/LTE%20in%20a%20Nutshell%20-%20Physical%20Layer.pdf>)

#### 4.2.1 Multiple Access

The multiple access scheme for the LTE physical layer is based on Orthogonal Frequency Division Multiplexing (OFDM) with a cyclic prefix (CP) in the downlink, and on Single-Carrier Frequency Division Multiple Access (SC-FDMA) with a cyclic prefix in the uplink. To support transmission in paired and unpaired spectrum, two duplex modes

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

## 6.11.1 Primary synchronization signal

### 6.11.1.1 Sequence generation

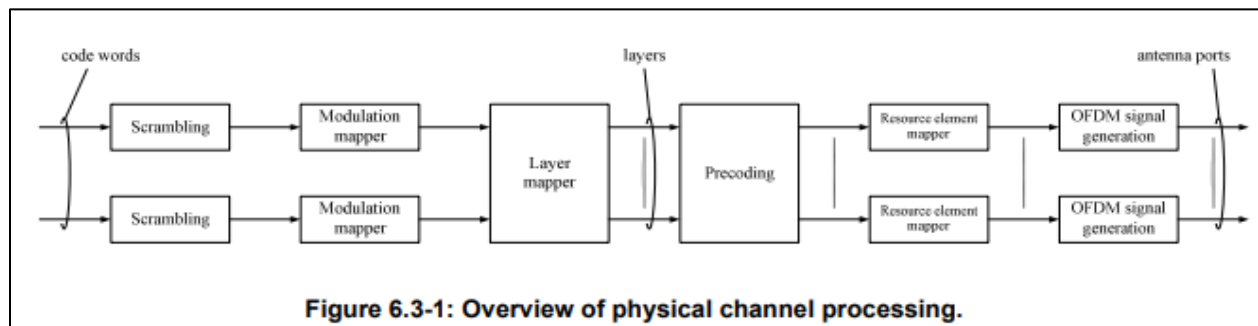
The sequence  $d(n)$  used for the primary synchronization signal is generated from a frequency-domain Zadoff-Chu sequence according to

$$d_u(n) = \begin{cases} e^{-j\frac{u(n+1)}{63}} & n = 0, 1, \dots, 30 \\ e^{-j\frac{u(n+1)(n+2)}{63}} & n = 31, 32, \dots, 61 \end{cases}$$

where the Zadoff-Chu root sequence index  $u$  is given by Table 6.11.1.1-1.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.pdf))



(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.pdf))



**Preamble and Pilot**

There are two different ways to transmit training symbols: preamble or pilot tones. Preambles entail sending a certain number of training symbols prior to the user data symbols. In the case of OFDM, one or two preamble OFDM symbols are typical. Pilot tones involve inserting a few known pilot symbols among the subcarriers. Channel estimation in MIMO-OFDM systems can be performed in a variety of ways, but it is typical to use the preamble for synchronization<sup>7</sup> and initial channel estimation, and the pilot tones for tracking the time-varying channel in order to maintain accurate channel estimates.

In MIMO-OFDM, the received signal at each antenna is a superposition of the signals transmitted from the  $N_t$  transmit antennas. Thus, the training signals for each transmit antenna need to be transmitted without interfering with each other in order to accurately estimate the channel. [Figure 5.18](#) shows three different patterns for MIMO-OFDM that avoid interfering with each other: independent, scattered, and orthogonal patterns [\[50\]](#).

(Source: Fundamentals of LTE, Ghosh et al.)

22. The methods practiced by Motorola Solutions's use of the accused products include transmitting the frame over a channel. The data frames having cyclic prefixes and other OFDM symbols are transmitted over a channel (e.g. PDCCH). Alternatively, on request from an accused product, an LTE base station can act as a transmitter and transmit the frame over a channel.

**4.2.1 Multiple Access**

The multiple access scheme for the LTE physical layer is based on Orthogonal Frequency Division Multiplexing (OFDM) with a cyclic prefix (CP) in the downlink, and on Single-Carrier Frequency Division Multiple Access (SC-FDMA) with a cyclic prefix in the uplink. To support transmission in paired and unpaired spectrum, two duplex modes

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

## 6.7 Physical control format indicator channel

The physical control format indicator channel carries information about the number of OFDM symbols used for transmission of PDCCHs in a subframe. The set of OFDM symbols possible to use for PDCCH in a subframe is given by Table 6.7-1.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/11.05.00\\_60/ts\\_136211v110500p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/11.05.00_60/ts_136211v110500p.pdf))

23. The methods practiced by Motorola Solutions's use of the accused products include receiving the transmitted frame. For example, the receiving antennas of the accused products can receive the transmitted frames for further processing.

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

**WIRELESS**

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<b>Bluetooth</b>	
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Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: [https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX\\_NEXT\\_XE\\_DS\\_FINAL.pdf](https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX_NEXT_XE_DS_FINAL.pdf))

**Wide Area Networks**

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10	452.2	2 or 4	102.0	
11	603.0	2 or 4	51.0	
12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)

24. The methods practiced by Motorola Solutions's use of the accused products include demodulating the received frame. For example, according to the LTE standards, the physical layer performs various functions which include modulation and demodulation of physical channels. Hence, the received frame will be demodulated for further processing.

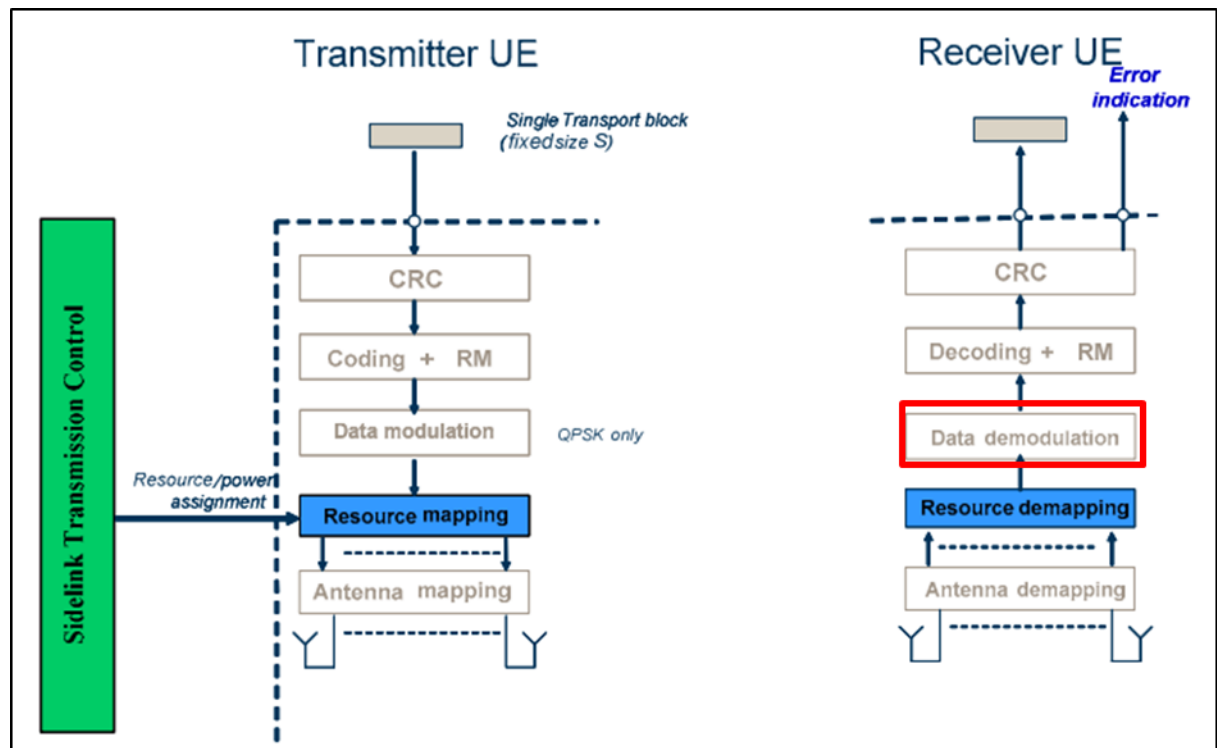
## 5.2 Overview of L1 functions

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.pdf](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf))



(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.pdf](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf))

25. The methods practiced by Motorola Solutions's use of the accused products include synchronizing the received demodulated frame to the transmitted frame such that the data symbols are synchronized in the time domain and frequency domain. For example, according to the LTE standards, the physical layer performs various functions which include frequency and time synchronization. The procedure of achieving this time and frequency synchronizations is called 'Cell Search'.

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

**WIRELESS**

<b>LTE</b>	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon®, Bell Mobility
<b>WiFi</b>	
Standards Supported	802.11a/b/g/n/ac
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<b>Bluetooth</b>	
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Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: [https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX\\_NEXT\\_XE\\_DS\\_FINAL.pdf](https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX_NEXT_XE_DS_FINAL.pdf))

**Wide Area Networks**

Standards	FDD-LTE/TDD-LTE/GSM/UMTS/HSPA+
LTE release	Includes LTE 3GPP Release 11 features, Category 9 Capable

(Source: <https://fccid.io/AZ489FT7104/User-Manual/Users-Manual-Eng-rev2-pdf-3927178>)

User equipment Category	Max. L1 data rate Downlink (Mbit/s)	Max. number of DL MIMO layers	Max. L1 data rate Uplink (Mbit/s)	3GPP Release
NB-I	0.68	1	1.0	Rel 13
MI	1.0	1	1.0	
0	1.0	1	1.0	Rel 12
1	10.3	1	5.2	Rel 8
2	51.0	2	25.5	
3	102.0	2	51.0	
4	150.8	2	51.0	
5	299.6	4	75.4	
6	301.5	2 or 4	51.0	Rel 10
7	301.5	2 or 4	102.0	
8	2,998.6	8	1,497.8	
9	452.2	2 or 4	51.0	Rel 11
10	452.2	2 or 4	102.0	
11	603.0	2 or 4	51.0	
12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)



## 5.2 Overview of L1 functions

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

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- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.pdf](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf))

## 4.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

A UE may assume the antenna ports 0 – 3 and the antenna port for the primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136213/14.02.00\\_60/ts\\_136213v140200p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/14.02.00_60/ts_136213v140200p.pdf))

26. The methods practiced by Motorola Solutions's use of the accused products include wherein the synchronizing in the time domain comprises coarse time synchronizing and

fine time synchronizing. For example, the physical layer performs time and frequency synchronization on received frames using the cell search procedure. It uses primary and secondary synchronization signals for time and frequency synchronization. The time synchronization includes coarse and fine time synchronizations. The PSS and the SSS are and have been used for symbol timing and radio frame timing respectively providing coarse and fine timing synchronization.

The physical channels defined in the downlink are:

- the Physical Downlink Shared Channel (PDSCH),
- the Physical Multicast Channel (PMCH),
- the Physical Downlink Control Channel (PDCCH),
- the Relay Physical Downlink Control Channel (R-PDCCH),
- the Physical Broadcast Channel (PBCH),
- the Physical Control Format Indicator Channel (PCFICH)
- and the Physical Hybrid ARQ Indicator Channel (PHICH).

The physical channels defined in the uplink are:

- the Physical Random Access Channel (PRACH),
- the Physical Uplink Shared Channel (PUSCH),
- and the Physical Uplink Control Channel (PUCCH).

In addition, signals are defined as reference signals, primary and secondary synchronization signals

The modulation schemes supported in the downlink and uplink are QPSK, 16QAM and 64QAM.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

## 4.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

A UE may assume the antenna ports 0 – 3 and the antenna port for the primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136213/14.02.00\\_60/ts\\_136213v140200p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/14.02.00_60/ts_136213v140200p.pdf))

In time- and frequency-synchronous multi-carrier transmission the receiver at the base station needs to detect the start position of an OFDM symbol or frame and to estimate the channel state information from some known pilot symbols inserted in each OFDM symbol. If the coherence time of the channel exceeds an OFDM symbol, the channel estimation can estimate the time variation as well. This strategy, which will be considered in the following, simplifies a burst receiver.

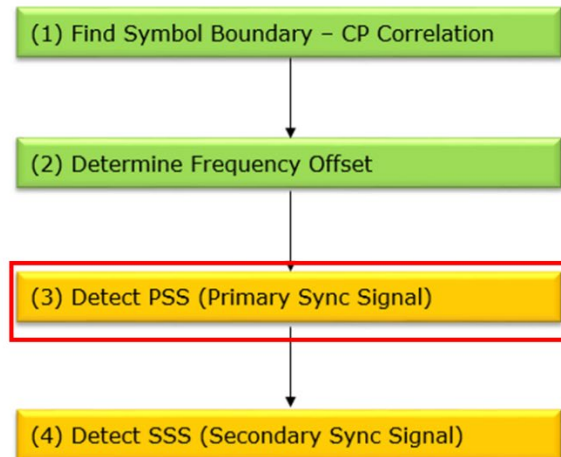
(Source: Multi-Carrier and Spread Spectrum Systems: From OFDM and MC-CDMA to LTE and WiMAX, Fazel et. Al (2008))

#### **4.2.4.2 Fine Symbol Timing**

For fine time synchronization, several methods based on transmitted reference symbols can be used [14]. One straightforward solution applies the estimation of the channel impulse response. The received signal without noise  $r(t) = s(t) \otimes h(t)$  is the convolution of the transmit signal  $s(t)$  and the channel impulse response  $h(t)$ . In the frequency domain after FFT processing we obtain  $R(f) = S(f)H(f)$ . By transmitting special reference symbols (e.g. CAZAC sequences [63]),  $S(f)$  is *a priori* known by the receiver. Hence,

(Source: Multi-Carrier and Spread Spectrum Systems: From OFDM and MC-CDMA to LTE and WiMAX, Fazel et. Al (2008))

If you go into a little bit further details, you would need a couple of additional steps as follows (step (1) and step (2)). To detect PSS and SSS, you need to get the data with a sequence of specific resource elements accurately. To accurately extract the data from a specific resource elements, you need to know the exact symbol boundary (starting sample and ending sample of an OFDM symbol). Once you detect the exact symbol boundary, you can detect the frequency offset (a kind of frequency error) to further compensate the signal. In some sense, these two steps are more difficult than PSS, SSS detection.



(Source: [http://www.sharetechnote.com/html/BasicProcedure\\_LTE\\_TimeSync.html](http://www.sharetechnote.com/html/BasicProcedure_LTE_TimeSync.html))

## Determining Frame Synchronization and Cell Identification

The cell search involves two steps:

1. Perform running correlation with three possible PSS and detect a peak in any of the three correlators. The position of the peak provides frame timing with an uncertainty of five subframes, as the PSS is present in both subframe 0 and subframe 5.
2. Once a peak is detected, perform correlation with 31 possible SSS in subframes 0 and 5 to find one of 168 possible combinations of two SSS.

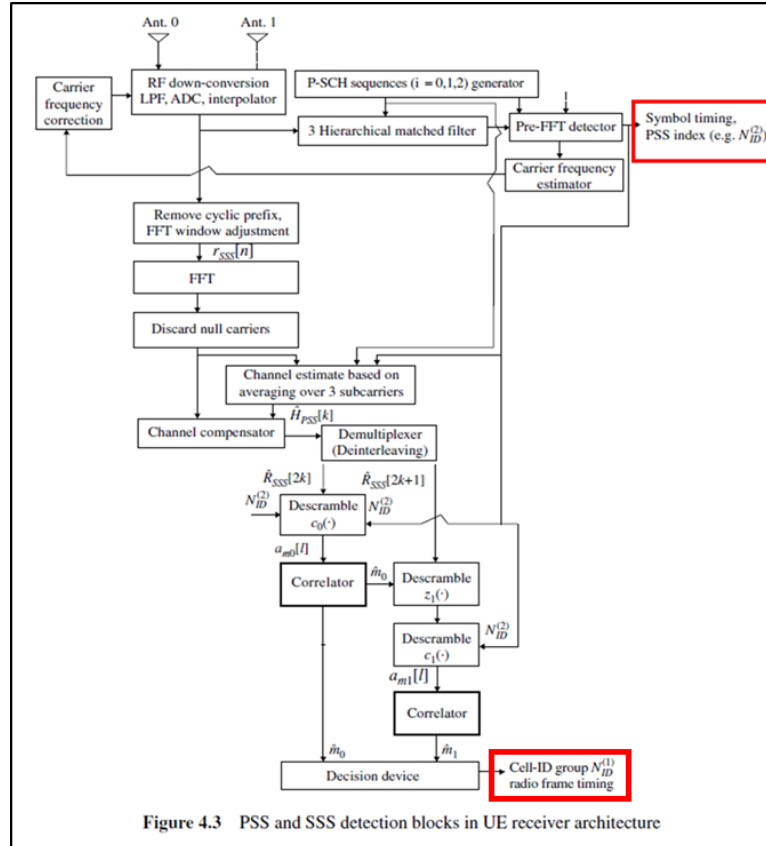
(Source: <https://www.mathworks.com/company/newsletters/articles/understanding-and-demodulating-lte-signals.html>)

### 15.1.1 DISCOVERY SIGNAL AND ASSOCIATED MEASUREMENTS

The *discovery reference signal* (DRS), although described as a new signal, actually consists of a combination already existing signals, namely

- synchronization signal (PSS and SSS) to assist in obtaining the cell identity and coarse frequency and time synchronization;
- cell-specific reference signals (CRS) to assist in obtaining fine frequency and time synchronization;
- CSI reference signals (optional) useful in determining the transmission point identity within the cell.

(Source: 4G, LTE-Advanced Pro and The Road to 5G, Dahlman et al. (2016))



(Source: Mobile Terminal Receiver Design: LTE and LTE-Advanced, Das, Sajal Kumar (2017))

#### Step1: Symbol Timing, Frequency Offset and Physical Layer ID Detection using PSS

In this stage, the symbol timing, frequency offset, and physical-layer ID are detected using PSS. As discussed above, the PSS occupies a bandwidth of  $62 \times 15$  kHz around the

(Source: Mobile Terminal Receiver Design: LTE and LTE-Advanced, Das, Sajal Kumar (2017))

#### Step-2: Radio Frame Timing and Cell Group ID Detection using SSS

Next, the radio-frame timing and cell group ID are detected using SSS in the frequency domain. As the SSS detection is generally performed in the frequency domain, FFT is

(Source: Mobile Terminal Receiver Design: LTE and LTE-Advanced, Das, Sajal Kumar (2017))

27. Motorola Solutions has had actual knowledge of the ‘782 Patent at least as of the date when it was notified of the filing of this action. By the time of trial, Motorola Solutions will have known and intended (since receiving such notice) that its continued actions would infringe and actively induce and contribute to the infringement of one or more claims of the ‘782 Patent.

28. Motorola Solutions has also indirectly and willfully infringed, and continues to indirectly and willfully infringe, the ‘782 Patent, as explained further below in the “Additional Allegations Regarding Infringement” section.

29. American Patents has been damaged as a result of the infringing conduct by Motorola Solutions alleged above. Thus, Motorola Solutions is liable to American Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

30. American Patents has neither made nor sold unmarked articles that practice the ‘782 Patent, and is entitled to collect pre-filing damages for the full period allowed by law for infringement of the ‘782 Patent.

**COUNT II**

**INFRINGEMENT OF U.S. PATENT NO. 7,310,304**

31. On December 18, 2007, United States Patent No. 7,310,304 (“the ‘304 Patent”) was duly and legally issued by the United States Patent and Trademark Office for an invention entitled “Estimating Channel Parameters in Multi-Input, Multi-Output (MIMO) Systems.”

32. American Patents is the owner of the ‘304 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the ‘304 Patent against infringers, and to collect damages for all relevant times.

33. Motorola Solutions made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its Motorola Solutions APX NEXT All-Band P25 Smart Radio, Motorola Solutions APX NEXT XE All-Band P25 Smart Radio, and Motorola Solutions LEX L11 Mission Critical LTE Device families of products, that include LTE capabilities (“accused products”):

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APX NEXT™ All-Band P25 Smart Radio
Product Details
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[MOTOROLA PRODUCTS](#) >
[TWO-WAY RADIOS](#) >
[PROJECT 25 RADIOS](#) >
[APX P25 PORTABLE RADIOS](#) >
[APX NEXT ALL-BAND P25 SMART RADIO](#)

# APX NEXT All-Band P25 Smart Radio

**Protect your focus when it matters most.**

Available in multi-band and single-band, APX NEXT advances usability and performance in every aspect of the radio. Accelerated workflows. Mission-critical reliability. All protecting the focus that keeps responders safe and effective.

HOW TO BUY

Experience APX NEXT

Body camera integration

Specifications


Get started

Share






(Source: [https://www.motorolasolutions.com/en\\_us/products/two-way-radios/project-25-radios/portable-radios/apx-next.html](https://www.motorolasolutions.com/en_us/products/two-way-radios/project-25-radios/portable-radios/apx-next.html))

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APX NEXT XE All-Band P25 Smart Radio

Product Details

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## APX NEXT XE All-Band P25 Smart Radio

**Focused in the extreme.**


Orderable in multi-band or single-band, APX NEXT XE merges glovable oversized controls with field intelligence for reliable use of your lifeline in extreme environments. Stay focused on your call, your firefighters, and your safety.


HOW TO BUY


Share




+4

 Tour APX NEXT XE






 Body camera integration



(Source: [https://www.motorolasolutions.com/en\\_us/products/two-way-radios/project-25-radios/portable-radios/apx-next-xe.html](https://www.motorolasolutions.com/en_us/products/two-way-radios/project-25-radios/portable-radios/apx-next-xe.html))


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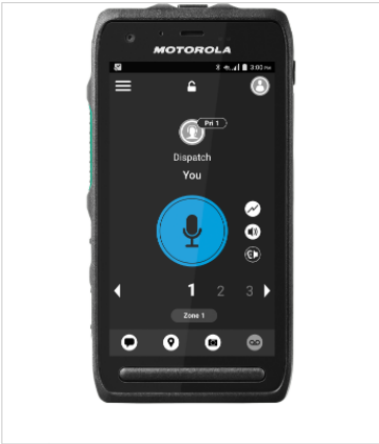






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# LEX L11 MISSION CRITICAL LTE DEVICE

## Made For The Mission Ahead




When hardware, software, and accessories work seamlessly together, the result is a device that works seamlessly for you.

The LEX L11 Mission Critical LTE Device is designed with first responders in mind. It's the result of our tireless quest to understand the way you actually work.

Every feature and function is thoughtfully considered, from the rugged, easy to operate design to the always loud and clear audio to the advanced end-to-end secure mobile platform and the enhanced accessibility provided by a suite of accessories.

Rugged and durable yet streamlined and slim, you can count on the LEX L11 to perform when it's needed most.

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[BROCHURE](#)  
[LEX L11 COMPARISON TOOL](#)  
[SPECIFICATIONS](#)  
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(Source: [https://www.motorolasolutions.com/en\\_us/products/lte-user-devices/lexl11.html#tabproductinfo](https://www.motorolasolutions.com/en_us/products/lte-user-devices/lexl11.html#tabproductinfo))

### WIRELESS

LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

<b>WIRELESS</b>	
<b>LTE</b>	
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(Source: [https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX\\_NEXT\\_XE\\_DS\\_FINAL.pdf](https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX_NEXT_XE_DS_FINAL.pdf))

<b>Wide Area Networks</b>	
Standards	FDD-LTE/TDD-LTE/GSM/UMTS/HSPA+
LTE release	Includes LTE 3GPP Release 11 features, Category 9 Capable

(Source: <https://fccid.io/AZ489FT7104/User-Manual/Users-Manual-Eng-rev2-pdf-3927178>)

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12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)

34. By doing so, Motorola Solutions has directly infringed (literally and/or under the doctrine of equivalents) at least Claim 1 of the ‘304 Patent. Motorola Solutions’s infringement in this regard is ongoing.

35. Motorola Solutions has infringed the ‘304 Patent by making, having made, using, importing, providing, supplying, distributing, selling or offering for sale products including an Orthogonal Frequency Division Multiplexing (OFDM) transmitter. For example, the accused products support LTE standards with MIMO technology.

**WIRELESS**

LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
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(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

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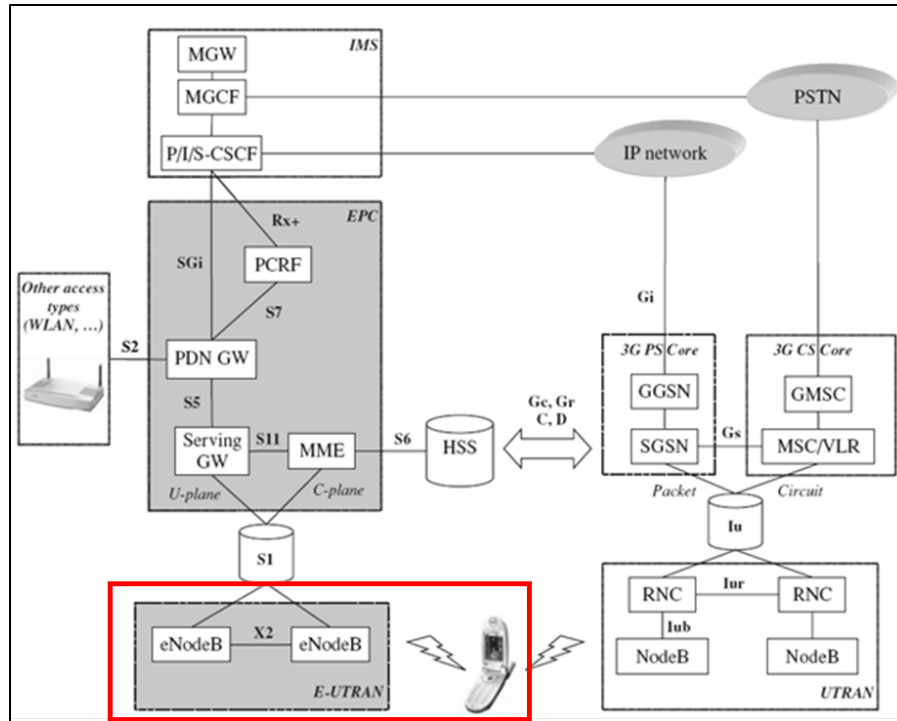
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10	452.2	2 or 4	102.0	
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(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)



(Source: <https://sites.google.com/site/lteencyclopedia/lte-network-infrastructure-and-elements>)

36. The accused products include an encoder configured to process data to be transmitted within an OFDM system, the encoder further configured to separate the data onto one or more transmit diversity branches (TDBs). Alternatively, on request from an accused product, an LTE base station includes a transmitter in an OFDM system with an encoder configured to process data to be transmitted within an OFDM system, the encoder further configured to separate the data onto one or more transmit diversity branches (TDBs). For example, according to the LTE standards, the physical layer performs FEC encoding on the transmitting data. Hence, there is an encoder block at the transmitter end; additionally, transmit diversity is performed at the transmitter end. The encoders output the data onto multiple transmit chains (i.e. transmit diversity branches) for further processing.

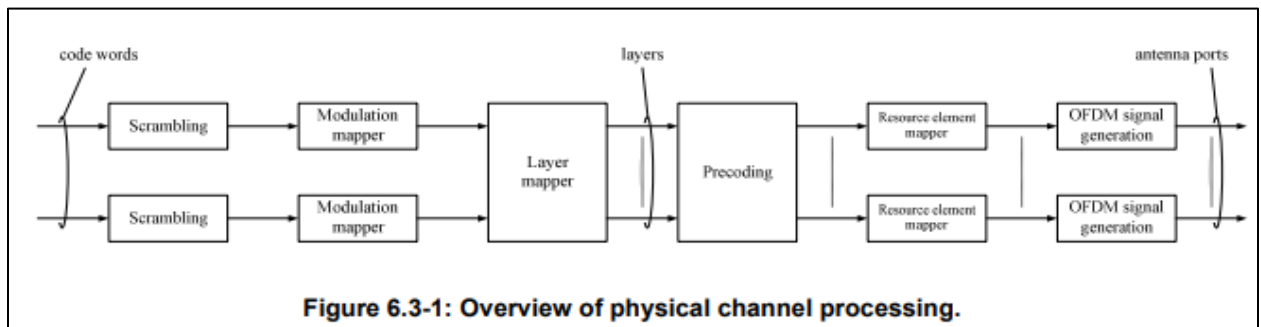
#### 4.1.2 Service provided to higher layers

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing
- Transmit Diversity (TX diversity)
- Beamforming
- RF processing. (Note: RF processing aspects are specified in the TS 36.100 series)

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))



(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.pdf))

37. The accused products include one or more OFDM modulators, each OFDM modulator connected to a respective TDB, each OFDM modulator configured to produce a frame



including a plurality of data symbols, a training structure, and cyclic prefixes inserted among the data symbols. For example, the physical layer performs the modulation and demodulation of the physical channels. Further, it uses OFDM in the downlink physical channel. Hence, there would be OFDM modulators for modulating the data signals. The physical layer transmits frames of data on the downlink that include cyclic prefixes, training symbols and other data groups.

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers

(Source:

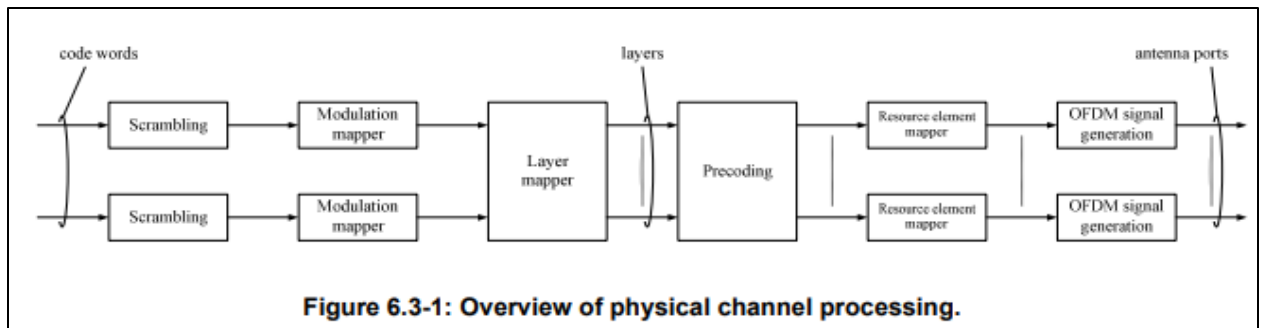
[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

#### 4.2.1 Multiple Access

The multiple access scheme for the LTE physical layer is based on Orthogonal Frequency Division Multiplexing (OFDM) with a cyclic prefix (CP) in the downlink, and on Single-Carrier Frequency Division Multiple Access (SC-FDMA) with a cyclic prefix in the uplink. To support transmission in paired and unpaired spectrum, two duplex modes

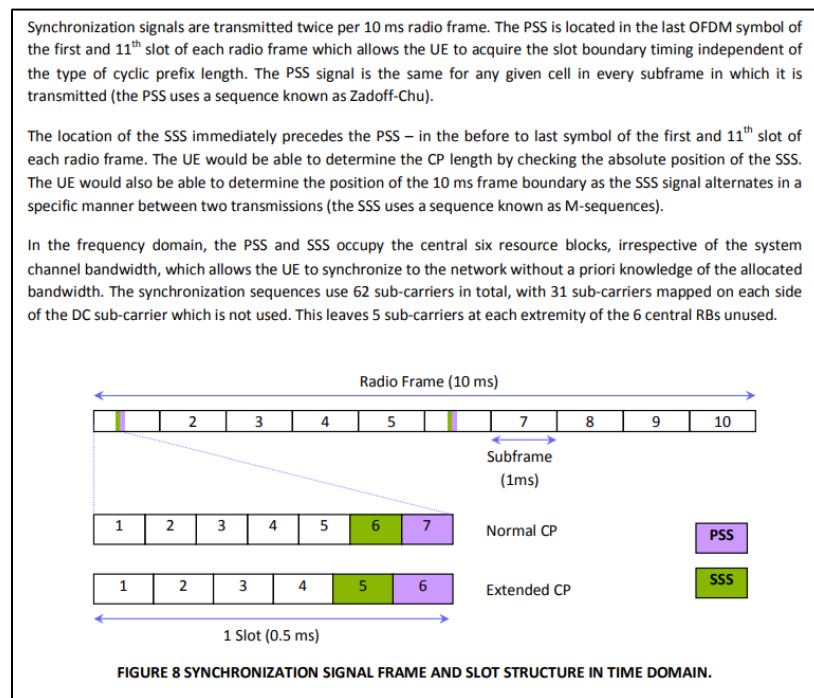
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(Source: <https://home.zhaw.ch/kunr/NTM1/literatur/LTE%20in%20a%20Nutshell%20-%20Physical%20Layer.pdf>)

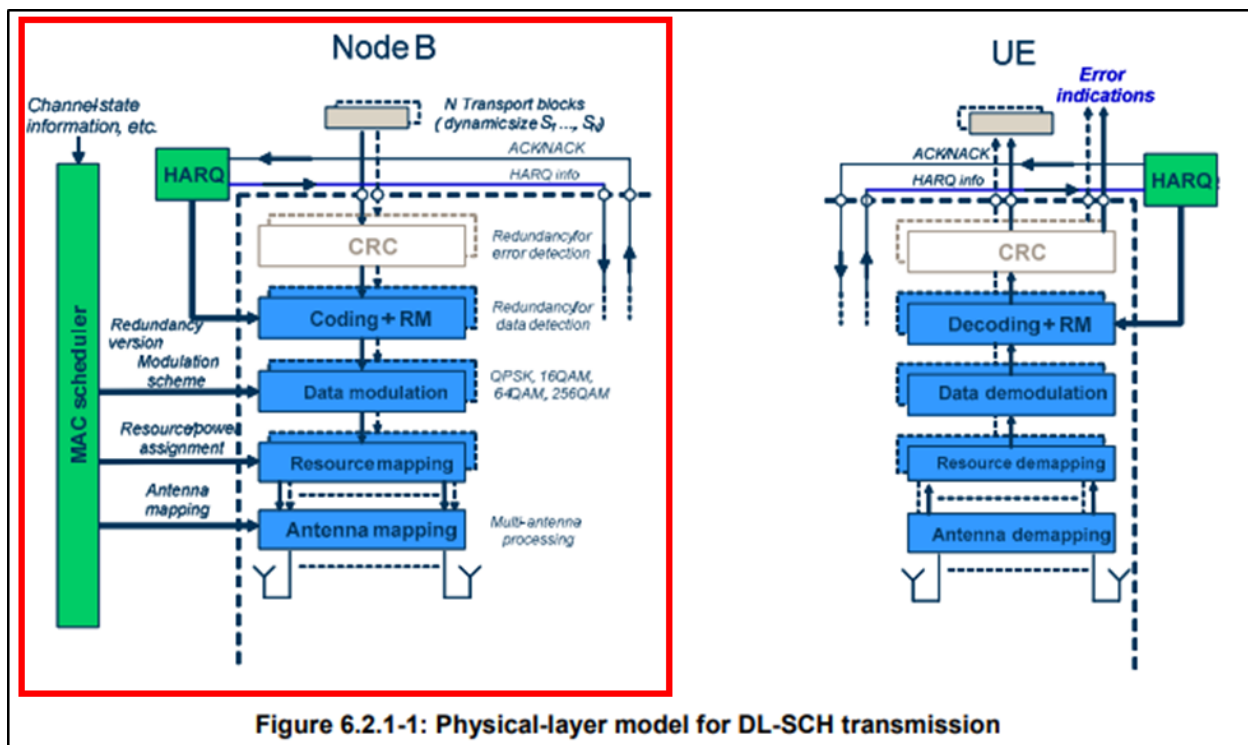
38. The accused products include one or more transmitting antennas in communication with the one or more OFDM modulators, respectively, each transmitting antenna configured to transmit the respective frame over a channel. Alternatively, on request from an accused product, an LTE base station includes one or more transmitting antennas in

communication with the one or more OFDM modulators, respectively, each transmitting antenna configured to transmit the respective frame over a channel. The transmitting antennas in the base station are connected to the OFDM modulators to get the OFDM frames for further transmission.

“Synchronization” refers to the technique applied to ensure the radios in the target LTE basestation are operating within the performance parameters defined by the appropriate 3rd Generation Partners Project (3GPP) standard. Synchronization is achieved by delivering a specifically formatted clock signal or signals to the basestation’s radio circuitry. These signals in turn are used to generate the modulation method’s RF air interface frequency/phase components.

The RF or air interface requirements of LTE are determined by the 3GPP, a collaboration between groups of telecommunications associations, known as the Organizational Partners. The 3GPP’s standardization encompasses radio, core network, and service architecture.

(Source: <https://www.electronicdesign.com/communications/lte-requires-synchronization-and-standards-support>)



(Source :

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.p](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf)

[df](#))

## 6.7 Physical control format indicator channel

The physical control format indicator channel carries information about the number of OFDM symbols used for transmission of PDCCHs in a subframe. The set of OFDM symbols possible to use for PDCCH in a subframe is given by Table 6.7-1.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/11.05.00\\_60/ts\\_136211v110500p.p](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/11.05.00_60/ts_136211v110500p.pdf)

[df](#))

39. The accused products include wherein the training structure of each frame includes a predetermined signal transmission matrix at a respective sub-channel, each training structure adjusted to have a substantially constant amplitude in a time domain, and the cyclic prefixes are further inserted within the training symbol, and wherein the cyclic prefixes within the training symbol are longer than the cyclic prefixes among the data symbols, thereby countering an extended channel impulse response and improving synchronization performance. Alternatively, on request from an accused product, an LTE base station includes a transmitter in an Orthogonal Frequency Division Multiplexing (OFDM) system, the transmitter comprising one or more OFDM modulators configured to produce a frame including a plurality of data symbols, a training structure, and cyclic prefixes inserted among the data symbols; wherein the training structure of each frame includes a predetermined signal transmission matrix at a respective sub-channel, each training structure adjusted to have a substantially constant amplitude in a time domain, and the cyclic prefixes are further inserted within the training symbol, and wherein the cyclic prefixes within the training symbol are longer than the cyclic prefixes among the data

symbols, thereby countering an extended channel impulse response and improving synchronization performance. For example, the physical layer performs precoding on both the downlink by generating a precoding matrix (i.e. signal transmission matrix) which is transmitted along with the data frames. Cyclic prefixes are added to the transmitting frames to help in frame synchronization at the receiver end. The evidence shows that a cell-specific reference signal acting as the training sequence are and have been used for channel estimation and are present in the first symbol of the slots in the frame. Also, the evidence shows that the cyclic prefix in the first symbol is longer than the cyclic prefix in the other data symbols. Thus, the cyclic prefix in the training structure reference signals are longer than the cyclic prefixes in the other data symbols. The primary synchronization signals and the cell specific reference signals are generated using Zadoff-Chu sequences which have a constant amplitude.

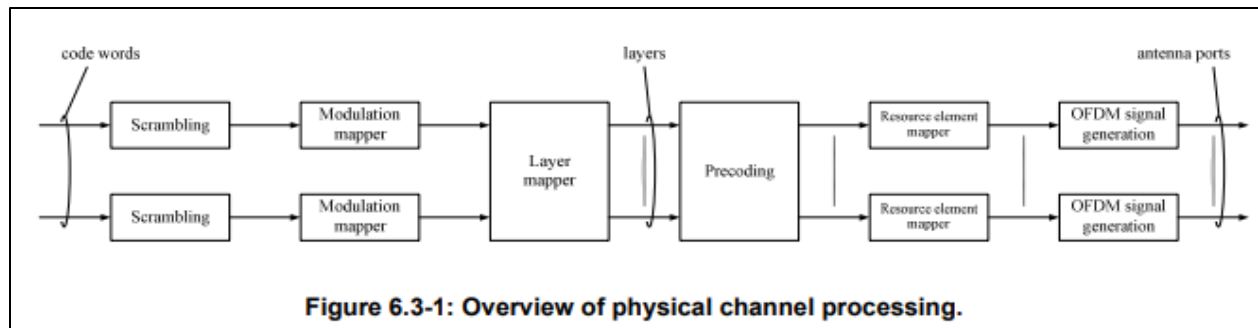
The scope of this specification is to establish the characteristics of the Layer-1 physical channels, generation of physical layer signals and modulation, and to specify:

- Definition of the uplink and downlink physical channels;
- The structure of the physical channels, frame format, physical resource elements, etc.;
- Modulation mapping (BPSK, QPSK, etc);
- Physical shared channel in uplink and downlink;
- Reference signal in uplink and downlink;
- Random access channel;
- Primary and secondary synchronization signals;
- OFDM signal generation in downlink;
- SC-FDMA signal generation in uplink;
- Scrambling, modulation and up conversion;
- Uplink-downlink timing relation;
- Layer mapping and precoding in downlink and uplink.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.p](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.p)

[df](#))



(Source:

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df)

### 6.3.4 Precoding

The precoder takes as input a block of vectors  $x(i) = [x^{(0)}(i) \dots x^{(v-1)}(i)]^T$ ,  $i = 0, 1, \dots, M_{\text{symp}}^{\text{layer}} - 1$  from the layer mapping and generates a block of vectors  $y(i) = [\dots y^{(p)}(i) \dots]^T$ ,  $i = 0, 1, \dots, M_{\text{symp}}^{\text{ap}} - 1$  to be mapped onto resources on each of the antenna ports, where  $y^{(p)}(i)$  represents the signal for antenna port  $p$ .

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.p](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.p)  
df)

#### 6.3.4.2.1 Precoding without CDD

Without cyclic delay diversity (CDD), precoding for spatial multiplexing is defined by

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(v-1)}(i) \end{bmatrix}$$

where the precoding matrix  $W(i)$  is of size  $P \times v$  and  $i = 0, 1, \dots, M_{\text{symp}}^{\text{ap}} - 1$ ,  $M_{\text{symp}}^{\text{ap}} = M_{\text{symp}}^{\text{layer}}$ .

For spatial multiplexing, the values of  $W(i)$  shall be selected among the precoder elements in the codebook configured in the eNodeB and the UE. The eNodeB can further confine the precoder selection in the UE to a subset of the elements in the codebook using codebook subset restrictions. The configured codebook shall be selected from Table 6.3.4.2.3-1 or 6.3.4.2.3-2.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.p](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.p)

df)

#### 6.3.4.2.2 Precoding for large delay CDD

For large-delay CDD, precoding for spatial multiplexing is defined by

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i)D(i)U \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(v-1)}(i) \end{bmatrix}$$

where the precoding matrix  $W(i)$  is of size  $P \times v$  and  $i = 0, 1, \dots, M_{\text{symb}}^{\text{ap}} - 1$ ,  $M_{\text{symb}}^{\text{ap}} = M_{\text{symb}}^{\text{layer}}$ . The diagonal size- $v \times v$  matrix  $D(i)$  supporting cyclic delay diversity and the size- $v \times v$  matrix  $U$  are both given by Table 6.3.4.2.2-1 for different numbers of layers  $v$ .

The values of the precoding matrix  $W(i)$  shall be selected among the precoder elements in the codebook configured in the eNodeB and the UE. The eNodeB can further confine the precoder selection in the UE to a subset of the elements in the codebook using codebook subset restriction. The configured codebook shall be selected from Table 6.3.4.2.3-1 or 6.3.4.2.3-2.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.p](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.p)

df)

The spatial correlation matrix for the complete system can be calculated using equation (1) above and forming the individual spatial correlation matrices at the eNB and the UE. For example, given a 2x2 MIMO system, assume the factors  $\alpha$  and  $\beta$  represent the correlation coefficients, calculated using (1), for the eNB and UE antenna pairs, respectively. The correlation matrices for eNB and the UE are represented as

$$R_{\text{BS}} = \begin{pmatrix} 1 & \alpha \\ \alpha^* & 1 \end{pmatrix}, \quad (2)$$

$$R_{\text{MS}} = \begin{pmatrix} 1 & \beta \\ \beta^* & 1 \end{pmatrix}. \quad (3)$$

The system spatial correlation matrix for the downlink channel can be calculated using the Kronecker product

$$R_{\text{S}} = R_{\text{BS}} \otimes R_{\text{MS}}, \quad (4)$$

$$R_{\text{S}} = \begin{pmatrix} 1 & \beta & \alpha & \alpha\beta \\ \beta^* & 1 & \alpha\beta^* & \alpha \\ \alpha^* & \alpha^*\beta & 1 & \beta \\ \alpha^*\beta^* & \alpha^* & \beta^* & 1 \end{pmatrix}. \quad (5)$$

These expressions are needed to determine the parameters for the user interface of a fading emulator.

(Source: LTE and the Evolution to 4G Wireless: Design and Measurement Challenges, Wiley (2013))



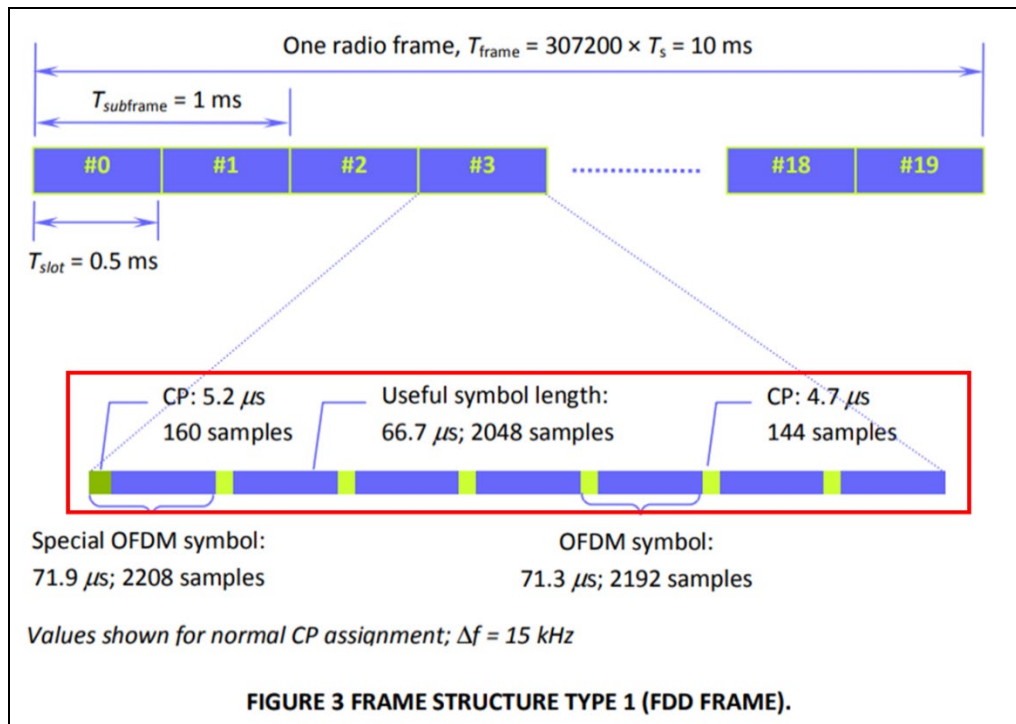
The useful symbol time is  $T_u = 2048 \cdot T_s \approx 66.7 \mu\text{s}$ . For the normal mode, the first symbol has a cyclic prefix of length  $T_{CP} = 160 \cdot T_s \approx 5.2 \mu\text{s}$ . The remaining six symbols have a cyclic prefix of length  $T_{CP} = 144 \cdot T_s \approx 4.7 \mu\text{s}$ . The reason for different CP length of the first symbol is to make the overall slot length in terms of time units divisible by 15360. For the extended mode, the cyclic prefix is  $T_{CP-e} = 512 \cdot T_s \approx 16.7 \mu\text{s}$ . The CP is longer than the typical delay spread of a few microseconds typically encountered in practice as shown in Figure 4. The normal cyclic prefix is used in urban cells and high data rate applications while the extended cyclic prefix is used in special cases like multi-cell broadcast and in very large cells (e.g. rural areas, low data rate applications).

(Source: <https://home.zhaw.ch/kunr/NTM1/literatur/LTE%20in%20a%20Nutshell%20-%20Physical%20Layer.pdf>)

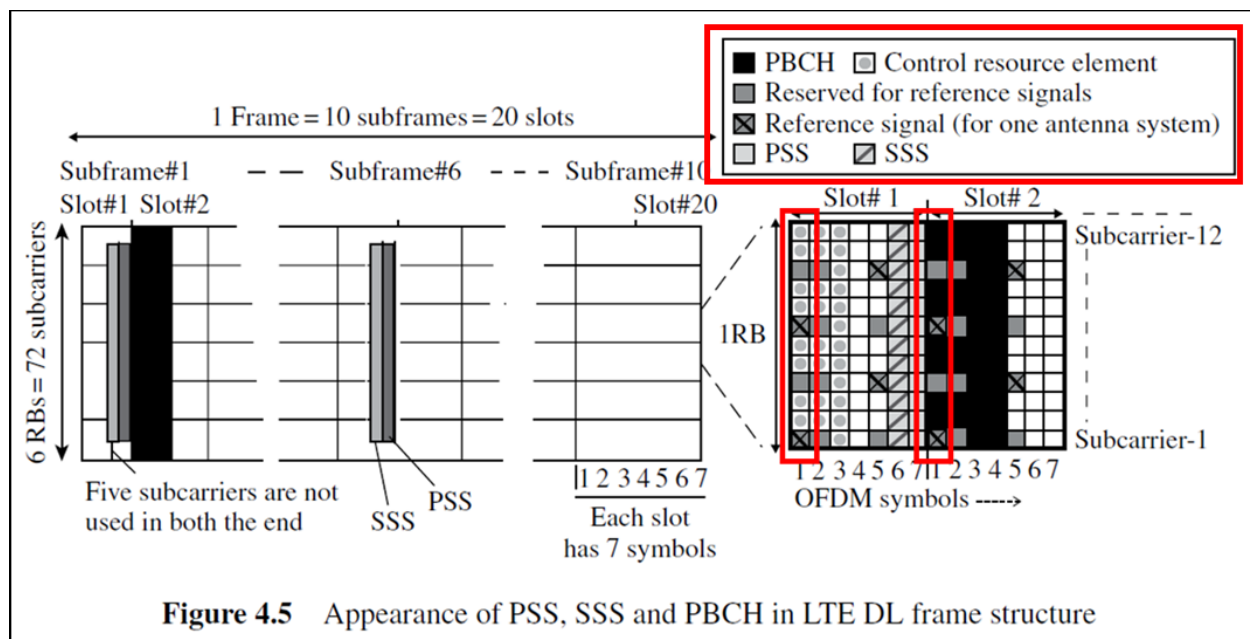
According to Chapter 4, a subcarrier spacing  $\Delta f = 15 \text{ kHz}$  corresponds to a useful symbol time  $T_u = 1/\Delta f \approx 66.7 \mu\text{s}$  ( $2048 \cdot T_s$ ). The overall OFDM symbol time is then the sum of the useful symbol time and the cyclic-prefix length  $T_{CP}$ . As illustrated in Figure 16.5, LTE defines two cyclic-prefix lengths, the normal cyclic prefix and an *extended* cyclic prefix, corresponding to seven and six OFDM symbols per slot, respectively. The exact cyclic-prefix lengths, expressed in the basic time unit  $T_s$ , are given in Figure 16.5. It should be noted that, in case of the normal cyclic prefix, the cyclic-prefix length for the first OFDM symbol of a slot is somewhat larger, compared to the remaining OFDM symbols. The reason for this is simply to fill the entire 0.5 ms slot as the number of time units  $T_s$  per slot (15360) is not dividable by seven.

(Source: 3G Evolution: HSPA and LTE for Mobile Broadband, Dahlman, et al. (2010))

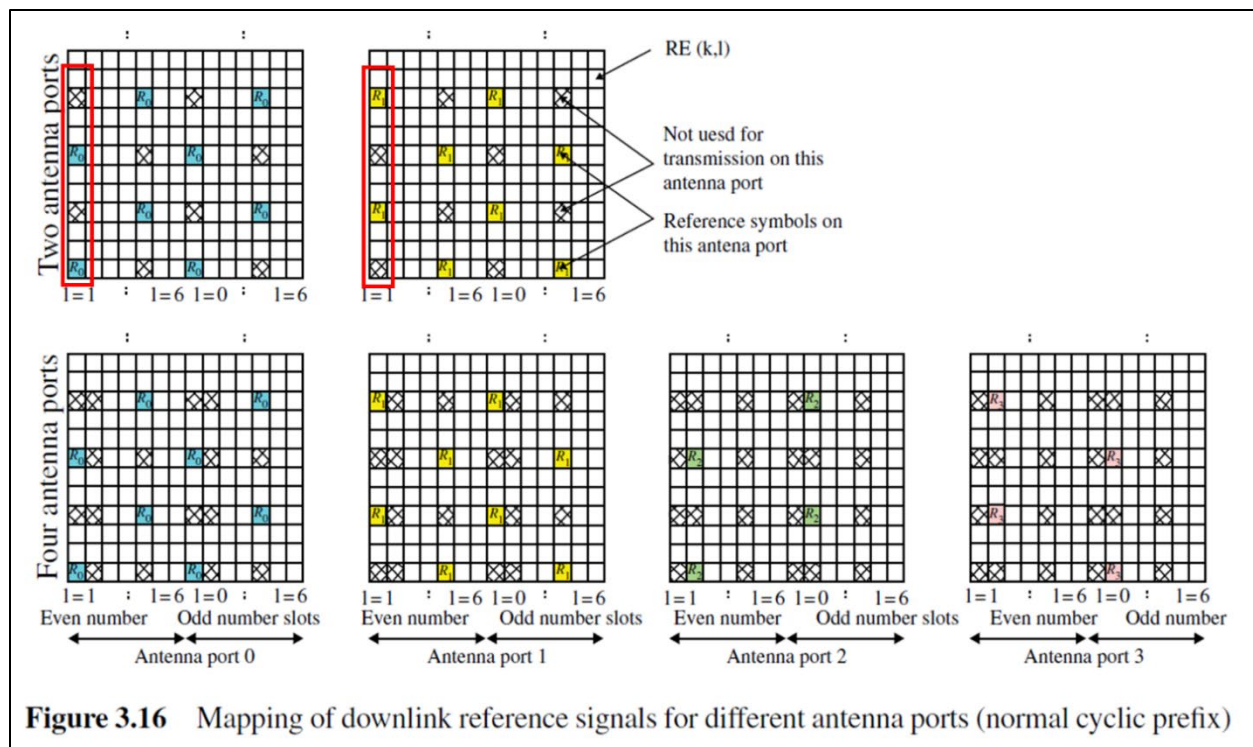




(Source: <https://home.zhaw.ch/kunr/NTM1/literatur/LTE%20in%20a%20Nutshell%20-%20Physical%20Layer.pdf>)



(Source: Mobile Terminal Receiver Design: LTE and LTE-Advanced, Das, Sajal Kumar (2017))



(Source: Mobile Terminal Receiver Design: LTE and LTE-Advanced, Das, Sajal Kumar (2017))

## 6.11.1 Primary synchronization signal

### 6.11.1.1 Sequence generation

The sequence  $d(n)$  used for the primary synchronization signal is generated from a frequency-domain Zadoff-Chu sequence according to

$$d_u(n) = \begin{cases} e^{-j\frac{u(n+1)}{63}} & n = 0, 1, \dots, 30 \\ e^{-j\frac{u(n+1)(n+2)}{63}} & n = 31, 32, \dots, 61 \end{cases}$$

where the Zadoff-Chu root sequence index  $u$  is given by Table 6.11.1.1-1.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.pdf))

### **Zadoff chu sequence properties:**

- It has constant amplitude.
- It has zero circular auto correlation.
- It has flat frequency domain response.
- circular cross correlation between two zadoff chu sequence is low.
- It has constant amplitude provided, L is a prime number.

### **LTE physical signals/channels where Zadoff chu is used**

**P-SS:** Primary synchronization signal, Zadoff chu sequence is used for this signal.

**RS:** Reference Signal, used both in uplink and downlink, Zadoff chu sequence is used.

**PUCCH:** Physical Uplink Control Channel, Zadoff chu sequence is used.

(Source: <http://www.rfwireless-world.com/Terminology/Zadoff-chu-sequence-LTE.html>)

40. Motorola Solutions has had actual knowledge of the ‘304 Patent at least as of the date when it was notified of the filing of this action. By the time of trial, Motorola Solutions will have known and intended (since receiving such notice) that its continued actions would infringe and actively induce and contribute to the infringement of one or more claims of the ‘304 Patent.

41. Motorola Solutions has also indirectly and willfully infringed, and continues to indirectly and willfully infringe, the ‘304 Patent, as explained further below in the “Additional Allegations Regarding Infringement” section.

42. American Patents has been damaged as a result of the infringing conduct by Motorola Solutions alleged above. Thus, Motorola Solutions is liable to American Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

43. American Patents has neither made nor sold unmarked articles that practice the ‘304 Patent, and is entitled to collect pre-filing damages for the full period allowed by law for infringement of the ‘304 Patent.


**COUNT III**

**INFRINGEMENT OF U.S. PATENT NO. 7,706,458**






44. On April 27, 2010, United States Patent No. 7,706,458 (“the ‘458 Patent”) was duly and legally issued by the United States Patent and Trademark Office for an invention entitled “Time And Frequency Synchronization In Multi-Input, Multi-Output (MIMO) Systems.”

45. American Patents is the owner of the ‘458 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the ‘458 Patent against infringers, and to collect damages for all relevant times.

46. Motorola Solutions made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its Motorola Solutions APX NEXT All-Band P25 Smart Radio, Motorola Solutions APX NEXT XE All-Band P25 Smart Radio, and Motorola Solutions LEX L11 Mission Critical LTE Device families of products, that include LTE capabilities (“accused products”):




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




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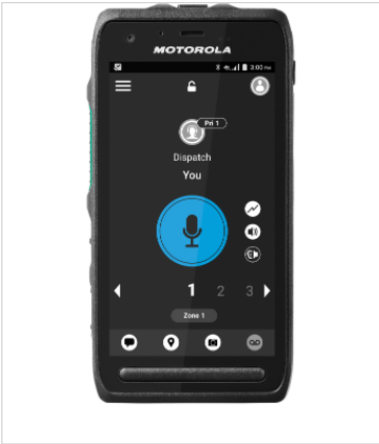
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### WIRELESS

LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

<b>WIRELESS</b>	
<b>LTE</b>	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon®, Bell Mobility
<b>WiFi</b>	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
<b>Bluetooth</b>	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

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<b>Wide Area Networks</b>	
Standards	FDD-LTE/TDD-LTE/GSM/UMTS/HSPA+
LTE release	Includes LTE 3GPP Release 11 features, Category 9 Capable

(Source: <https://fccid.io/AZ489FT7104/User-Manual/Users-Manual-Eng-rev2-pdf-3927178>)



User equipment Category	Max. L1 data rate Downlink (Mbit/s)	Max. number of DL MIMO layers	Max. L1 data rate Uplink (Mbit/s)	3GPP Release
NB-I	0.68	1	1.0	Rel 13
MI	1.0	1	1.0	
0	1.0	1	1.0	Rel 12
1	10.3	1	5.2	Rel 8
2	51.0	2	25.5	
3	102.0	2	51.0	
4	150.8	2	51.0	
5	299.6	4	75.4	
6	301.5	2 or 4	51.0	Rel 10
7	301.5	2 or 4	102.0	
8	2,998.6	8	1,497.8	
9	452.2	2 or 4	51.0	Rel 11
10	452.2	2 or 4	102.0	
11	603.0	2 or 4	51.0	
12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)

47. By doing so, Motorola Solutions has directly infringed (literally and/or under the doctrine of equivalents) at least Claim 1 of the ‘458 Patent. Motorola Solutions’s infringement in this regard is ongoing.

48. Motorola Solutions has infringed the ‘458 Patent by making, having made, using, importing, providing, supplying, distributing, selling or offering for sale products including an apparatus for synchronizing a communication system. The accused product is a receiver in an apparatus for synchronizing a communication system. An LTE compliant base station that is communicating with an accused product can be part of the apparatus, acting as a transmitter. For

example, according to the LTE standards, the physical layer performs various functions which include modulation and demodulation of physical channels, as well as time and frequency synchronization.

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon®, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: [https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX\\_NEXT\\_XE\\_DS\\_FINAL.pdf](https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX_NEXT_XE_DS_FINAL.pdf))

**Wide Area Networks**

Standards	FDD-LTE/TDD-LTE/GSM/UMTS/HSPA+
LTE release	Includes LTE 3GPP Release 11 features, Category 9 Capable

(Source: <https://fccid.io/AZ489FT7104/User-Manual/Users-Manual-Eng-rev2-pdf-3927178>)

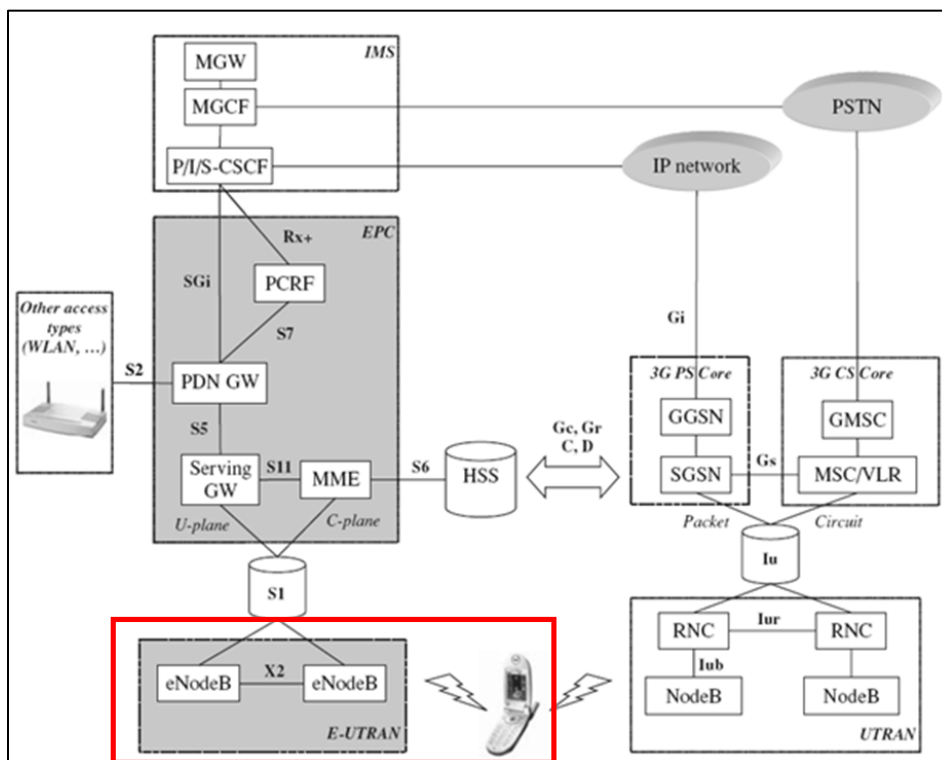
User equipment Category	Max. LI datarate Downlink (Mbit/s)	Max. number of DL MIMO layers	Max. LI datarate Uplink (Mbit/s)	3GPP Release
NB-I	0.68	1	1.0	Rel 13
MI	1.0	1	1.0	
0	1.0	1	1.0	Rel 12
1	10.3	1	5.2	Rel 8
2	51.0	2	25.5	
3	102.0	2	51.0	
4	150.8	2	51.0	
5	299.6	4	75.4	
6	301.5	2 or 4	51.0	Rel 10
7	301.5	2 or 4	102.0	
8	2,998.6	8	1,497.8	
9	452.2	2 or 4	51.0	Rel 11
10	452.2	2 or 4	102.0	
11	603.0	2 or 4	51.0	
12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)

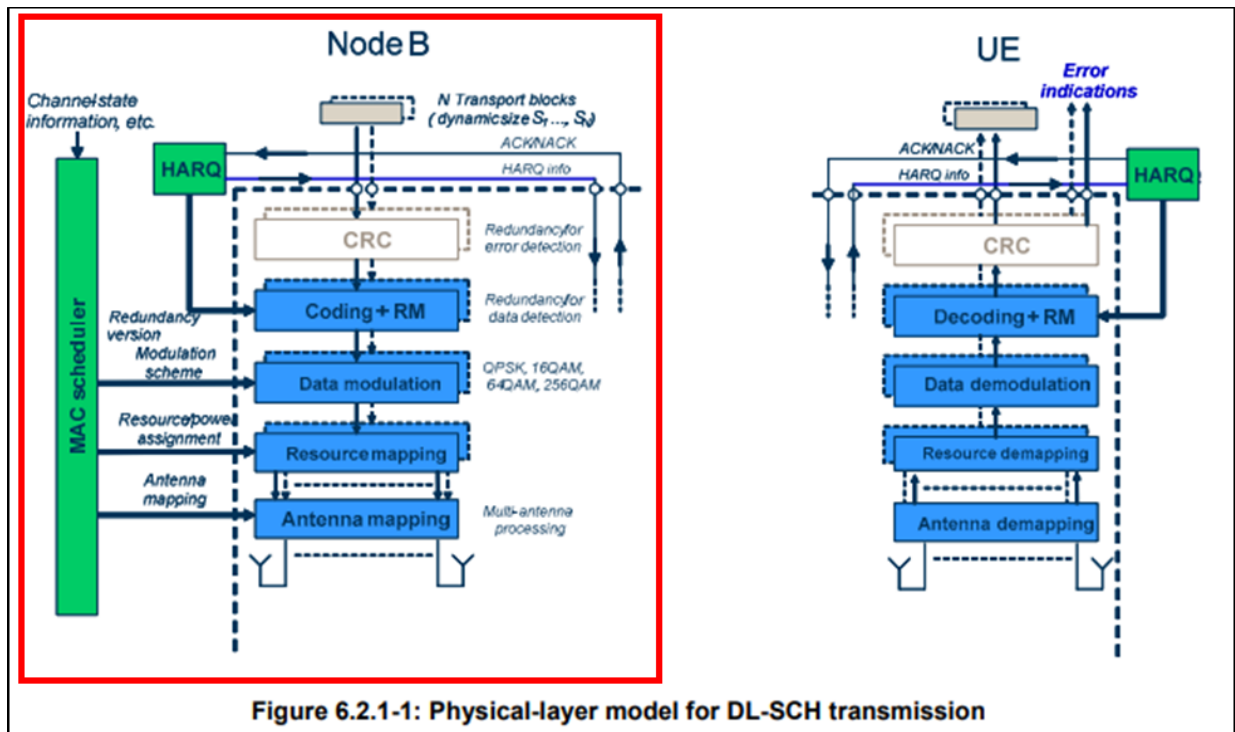
“Synchronization” refers to the technique applied to ensure the radios in the target LTE basestation are operating within the performance parameters defined by the appropriate 3rd Generation Partners Project (3GPP) standard. Synchronization is achieved by delivering a specifically formatted clock signal or signals to the basestation’s radio circuitry. These signals in turn are used to generate the modulation method’s RF air interface frequency/phase components.

The RF or air interface requirements of LTE are determined by the 3GPP, a collaboration between groups of telecommunications associations, known as the Organizational Partners. The 3GPP’s standardization encompasses radio, core network, and service architecture.

(Source: <https://www.electronicdesign.com/communications/lte-requires-synchronization-and-standards-support>)



(Source: <https://sites.google.com/site/lteencyclopedia/lte-network-infrastructure-and-elements>)



(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.pdf](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf))

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

49. The accused products include a number (Q) of Orthogonal Frequency Division Multiplexing (OFDM) modulators, each OFDM modulator producing a frame having at least one inserted symbol, a plurality of data symbols, and cyclic prefixes. Alternatively, on being requested by an accused product, an LTE base station acts as a transmitter and includes a number (Q) of Orthogonal Frequency Division Multiplexing (OFDM) modulators, each OFDM modulator producing a frame having at least one inserted symbol, a plurality of data symbols, and cyclic prefixes. The LTE base station eNodeB acts as the transmitter for the OFDM frames. The physical layer performs the modulation and demodulation of the physical channels. Further, it uses OFDM in the downlink physical channel. Hence, there would be OFDM modulators for modulating the data signals at the base station. The physical layer transmits frames of data on the downlink, that includes data symbols, synchronization symbols such as PSS, SSS and cyclic prefixes.

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers

(Source:

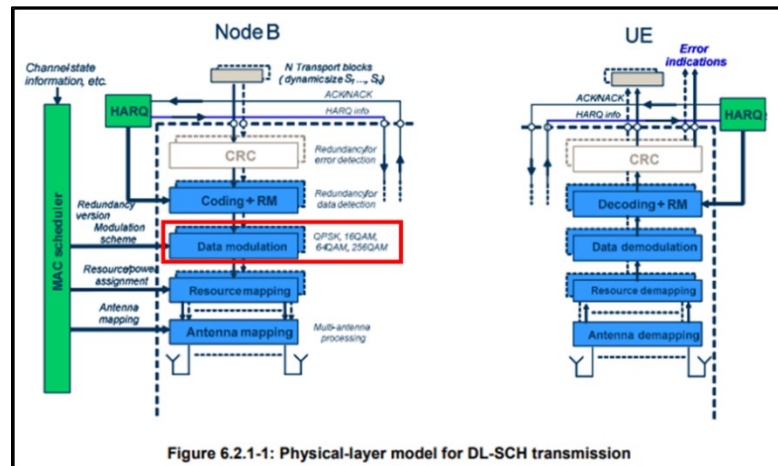
[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

#### 4.2.1 Multiple Access

The multiple access scheme for the LTE physical layer is based on Orthogonal Frequency Division Multiplexing (OFDM) with a cyclic prefix (CP) in the downlink, and on Single-Carrier Frequency Division Multiple Access (SC-FDMA) with a cyclic prefix in the uplink. To support transmission in paired and unpaired spectrum, two duplex modes

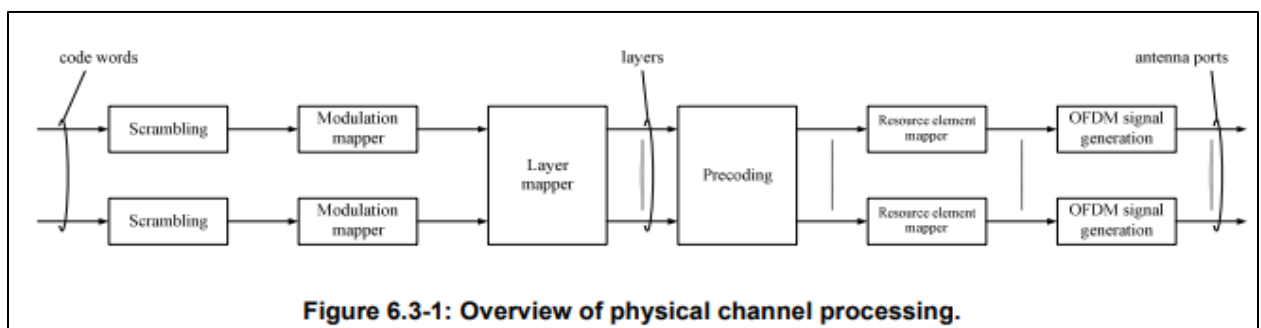
(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))



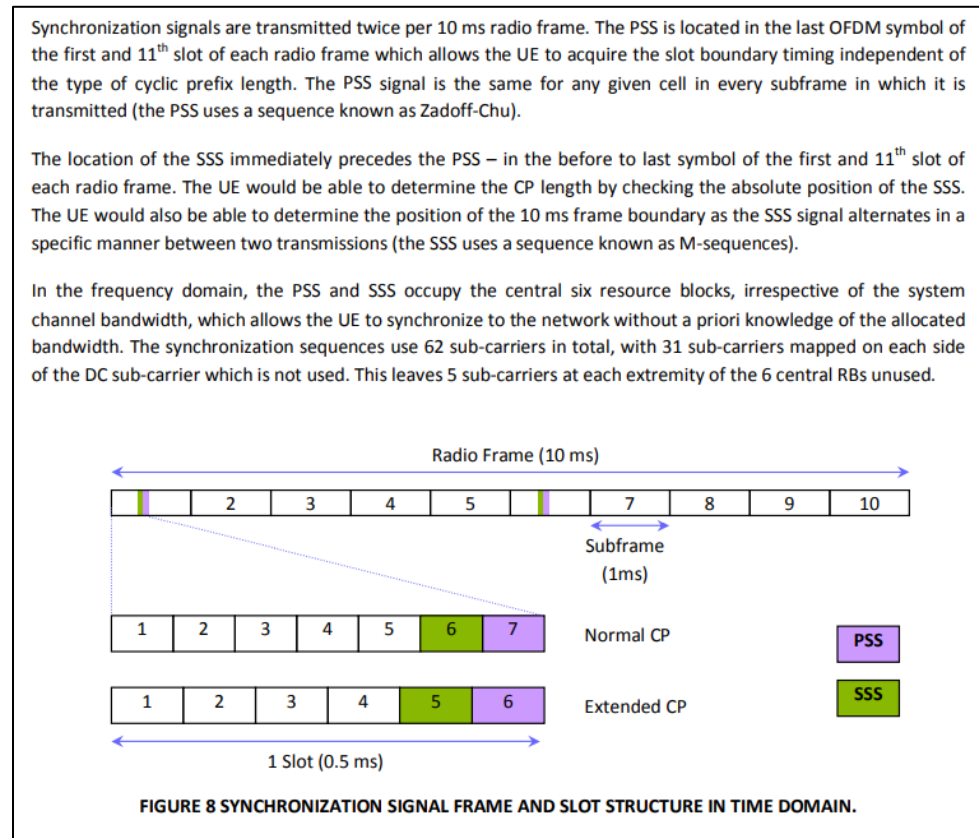
(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.pdf](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf))



(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/08.06.00\\_60/ts\\_136211v080600p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.06.00_60/ts_136211v080600p.pdf))



(Source: <https://home.zhaw.ch/kunr/NTM1/literatur/LTE%20in%20a%20Nutshell%20-%20Physical%20Layer.pdf>)

50. The accused products include Q transmitting antennas, each transmitting antenna connected to a respective OFDM modulator, the transmitting antennas configured to transmit a respective frame over a channel. Alternatively, on being requested by an accused product, the LTE base station can act as a transmitter and include Q transmitting antennas, each transmitting antenna connected to a respective OFDM modulator, the transmitting antennas configured to transmit a respective frame over a channel. The LTE base station eNodeB acts as the transmitter for the data frames. The data frames having cyclic prefixes and other OFDM symbols are



transmitted over a channel (PDCCH, etc.). The transmitting antennas of a base station would transmit multiple OFDM frames over a channel. Thus, these transmitting antennas would be connected to OFDM modulators to get the OFDM frames for further transmission.

## 6.7 Physical control format indicator channel

The physical control format indicator channel carries information about the number of OFDM symbols used for transmission of PDCCHs in a subframe. The set of OFDM symbols possible to use for PDCCH in a subframe is given by Table 6.7-1.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136211/11.05.00\\_60/ts\\_136211v110500p.p](https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/11.05.00_60/ts_136211v110500p.pdf)

df)

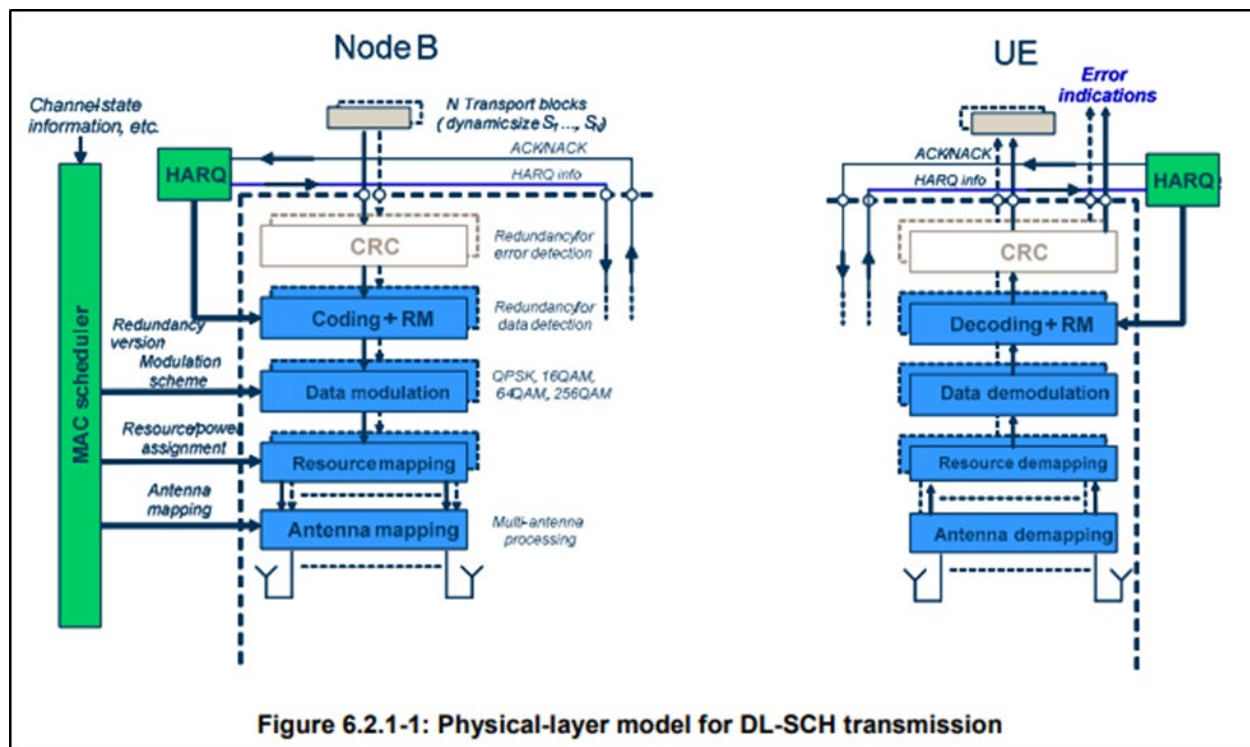


Figure 6.2.1-1: Physical-layer model for DL-SCH transmission

(Source :

[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v150000p.p](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v150000p.pdf)

df)

51. The accused products include a number (L) of receiving antennas for receiving the transmitted frames. For example, the accused products comply with LTE standards and uses MIMO antenna system. These receiving antennas would receive the frames transmitted by the base station.

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

WIRELESS	
LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon®, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: [https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX\\_NEXT\\_XE\\_DS\\_FINAL.pdf](https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/resources/APX_NEXT_XE_DS_FINAL.pdf))

#### Wide Area Networks

Standards	FDD-LTE/TDD-LTE/GSM/UMTS/HSPA+
LTE release	Includes LTE 3GPP Release 11 features, Category 9 Capable

(Source: <https://fccid.io/AZ489FT7104/User-Manual/Users-Manual-Eng-rev2-pdf-3927178>)

User equipment Category	Max. LI datarate Downlink (Mbit/s)	Max. number of DL MIMO layers	Max. LI datarate Uplink (Mbit/s)	3GPP Release
NB-I	0.68	1	1.0	Rel 13
MI	1.0	1	1.0	
0	1.0	1	1.0	Rel 12
1	10.3	1	5.2	Rel 8
2	51.0	2	25.5	
3	102.0	2	51.0	
4	150.8	2	51.0	
5	299.6	4	75.4	
6	301.5	2 or 4	51.0	Rel 10
7	301.5	2 or 4	102.0	
8	2,998.6	8	1,497.8	
9	452.2	2 or 4	51.0	Rel 11
10	452.2	2 or 4	102.0	
11	603.0	2 or 4	51.0	
12	603.0	2 or 4	102.0	

(Source: <https://www.cablefree.net/wirelesstechnology/4glte/lte-us-category-class-definitions>)

52. The accused products include L OFDM demodulators, each OFDM demodulator corresponding to a respective receiving antenna, the L OFDM demodulators including a

synchronization circuit that processes the received frame in order to synchronize the received frame in both time domain and frequency domain. For example, according to the LTE standards, the physical layer performs various functions which include modulation and demodulation, as well as frequency and time synchronization. Hence, there would be demodulator blocks and synchronization circuits for performing these functions. The procedure of achieving time and frequency synchronizations is called ‘Cell Search’.

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

## 4.1 Cell search

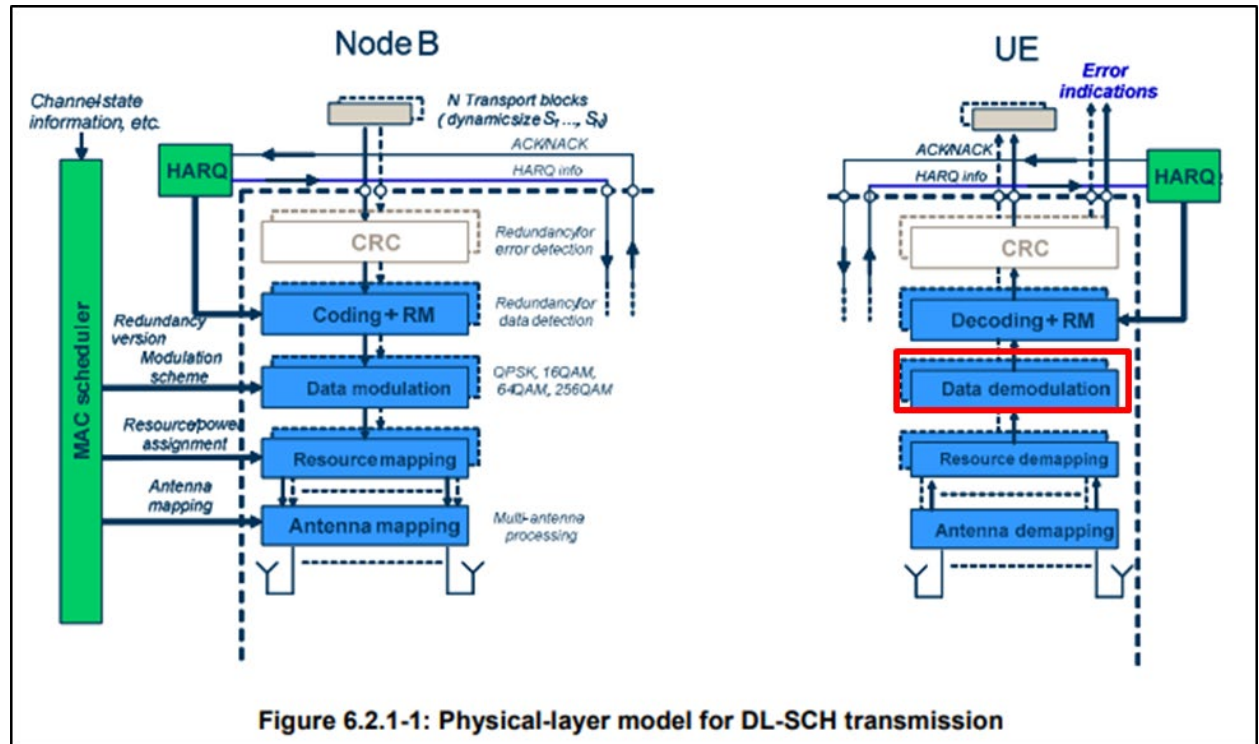
Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

A UE may assume the antenna ports 0 – 3 and the antenna port for the primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136213/14.02.00\\_60/ts\\_136213v140200p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/14.02.00_60/ts_136213v140200p.pdf))



(Source:

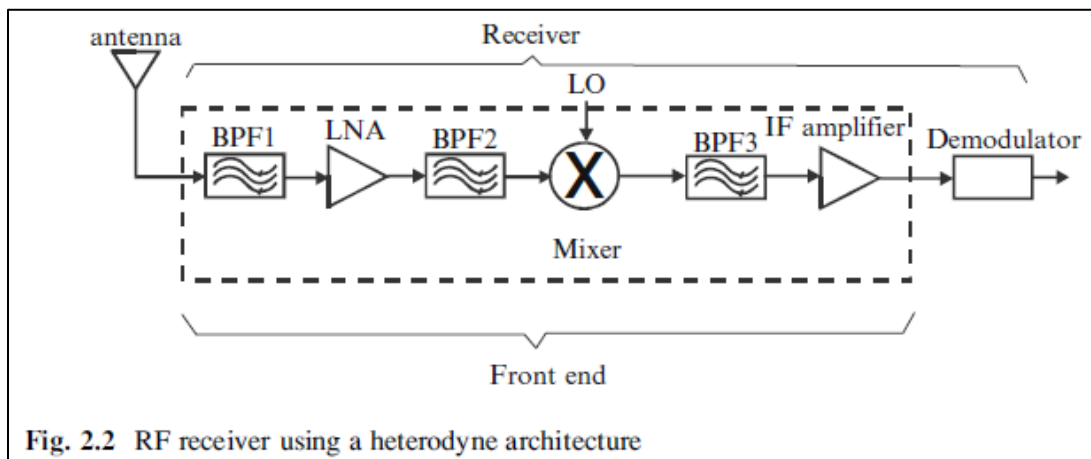
[https://www.etsi.org/deliver/etsi\\_ts/136300\\_136399/136302/15.00.00\\_60/ts\\_136302v15000p.pdf](https://www.etsi.org/deliver/etsi_ts/136300_136399/136302/15.00.00_60/ts_136302v15000p.pdf))

53. The accused products include wherein each of the L OFDM demodulators comprises a pre-amplifier, a local oscillator, a mixer having a first input and a second input, the first input connected to an output of the pre-amplifier, the second input connected to an output of the local oscillator, an analog-to-digital converter (ADC) connected to an output of the mixer. LTE devices generally include RF Front-end Modules. After the data is transmitted by the base station, the data is received by a receiving antenna of the accused product for further processing. To prevent the demodulator from demodulating the noise associated with the received signal, an

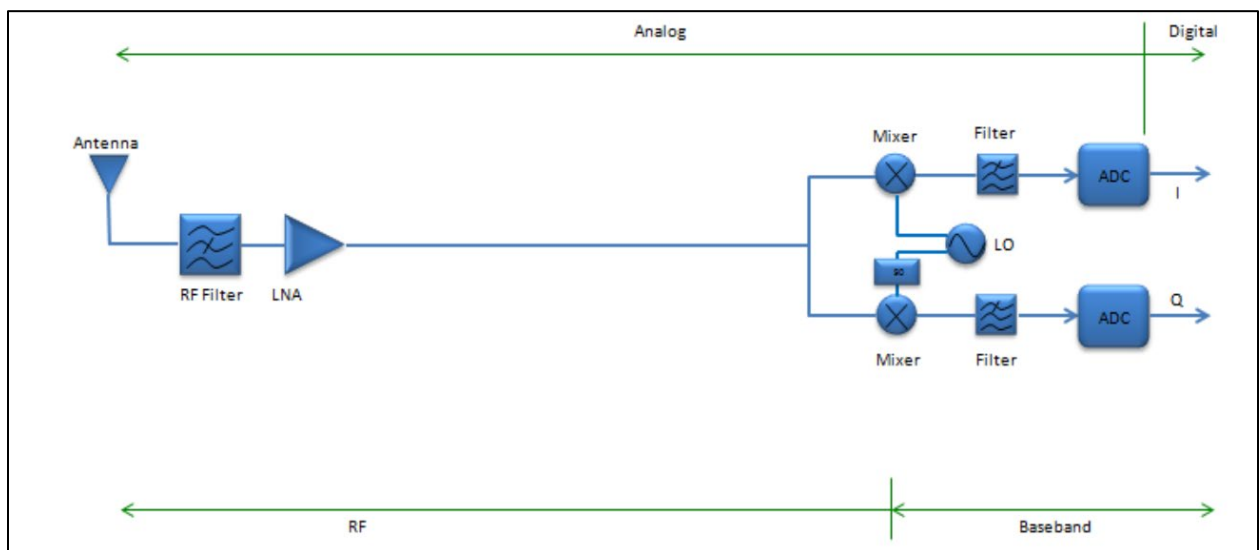
RF front end circuit is implemented to increase the SNR of demodulated signal. The RF front end circuit generally consists of amplifiers, local oscillator, filters and mixers. The output from the mixer is generally fed to an analog-to-digital converter (ADC). This RF front end circuit generally lies at the start of the demodulation process.

The technique to combat a low  $SNR_{\text{demod\_in}}$  is by adding a front end block, which processes (conditions) the received signal/AWGN/interference before admitting it to the demodulator. This processing can be done in several ways:

(Source: VLSI for Wireless Communication)



(Source: VLSI for Wireless Communication)



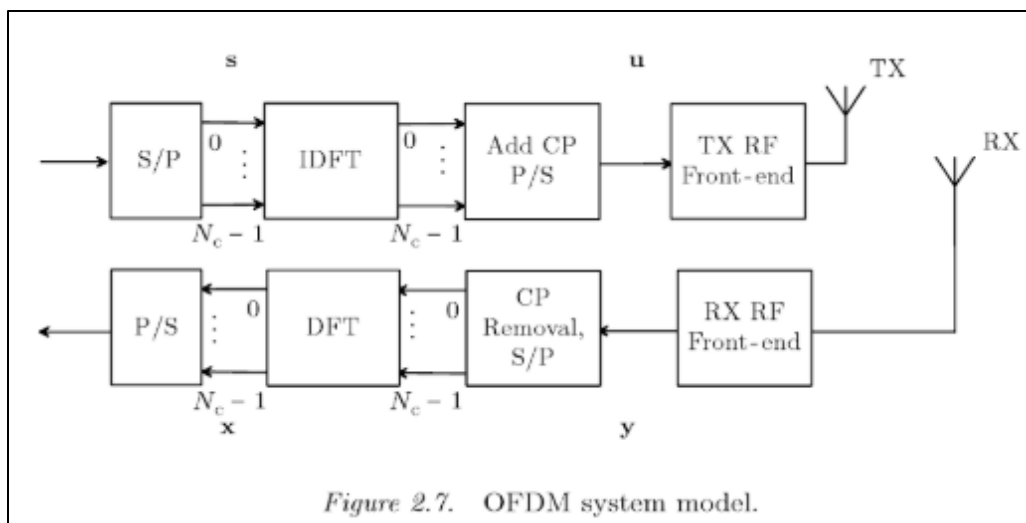


(Source: [http://www.sharetechnote.com/html/RF\\_Introduction.html](http://www.sharetechnote.com/html/RF_Introduction.html))

## 2.4 Rest of Receiver Front End: Nonidealities and Design Parameters

Now that we have talked about the design of filters in the receiver front, we turn our attention to the design of the rest of the components. Normally these components consist of circuits such as LNA, mixer, IF amplifier, and analog/digital (A/D) converter. Unlike filters, their relevant design parameters are different. Hence our first task is to discuss these design parameters.

(Source: VLSI for Wireless Communication)



(Source: RF Imperfections in High-rate Wireless Systems: Impact and Digital Compensation, Schenk (2008))

The RF front end is generally defined as everything between the antenna and the digital baseband system. For a receiver, this "between" area includes all the filters, low-noise amplifiers (LNAs), and down-conversion mixer(s) needed to process the modulated signals received at the antenna into signals suitable for input into the baseband analog-to-digital converter (ADC). For this reason, the RF front end is often called the analog-to-digital or RF-to-baseband portion of a receiver.

(Source: [https://www.eetimes.com/document.asp?doc\\_id=1276331](https://www.eetimes.com/document.asp?doc_id=1276331))

54. The accused products include the synchronization circuit having one input connected to an output of the ADC. According to the LTE standards, the physical layer performs various functions which include frequency and time synchronization. The procedure of achieving this time and frequency synchronizations is called 'Cell Search'. Hence, there are synchronization circuits for performing these functions. The synchronization circuit is connected to an ADC.

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers

(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136201/10.00.00\\_60/ts\\_136201v100000p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136201/10.00.00_60/ts_136201v100000p.pdf))

## 4.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

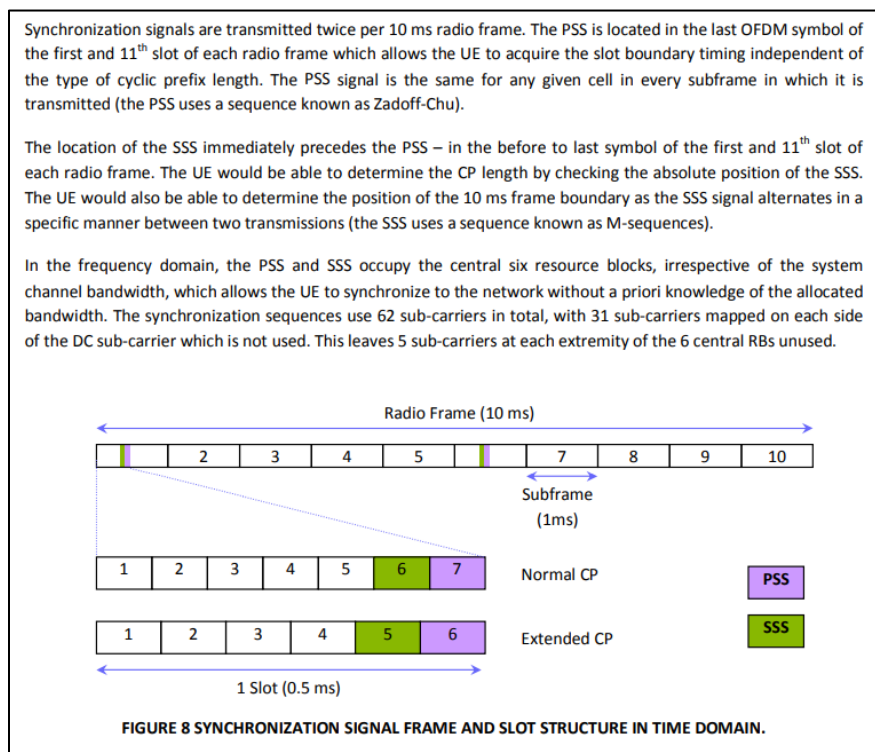
A UE may assume the antenna ports 0 – 3 and the antenna port for the primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.



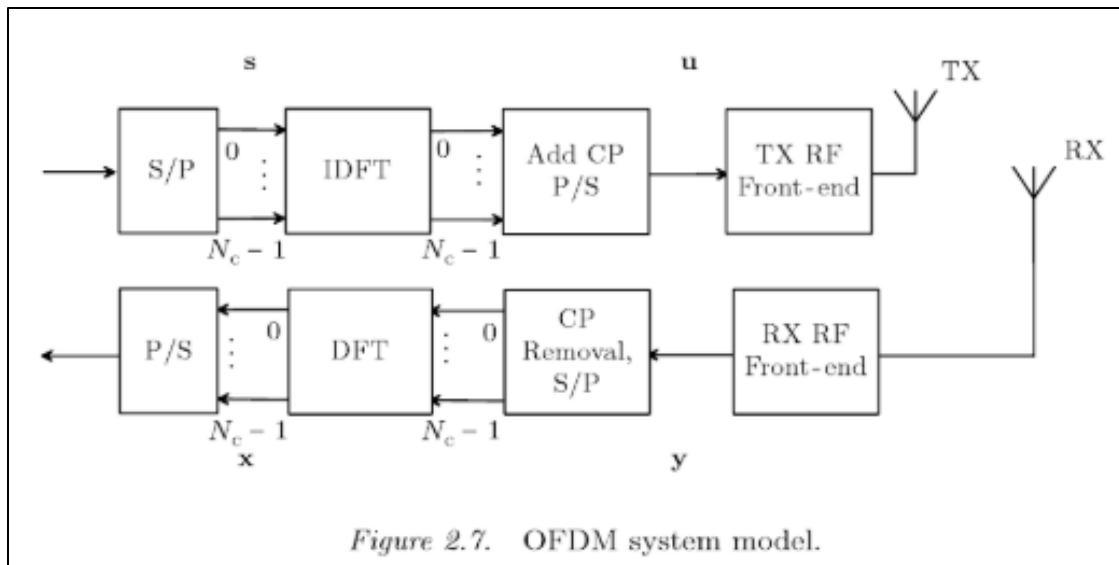
(Source:

[https://www.etsi.org/deliver/etsi\\_ts/136200\\_136299/136213/14.02.00\\_60/ts\\_136213v140200p.pdf](https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/14.02.00_60/ts_136213v140200p.pdf))

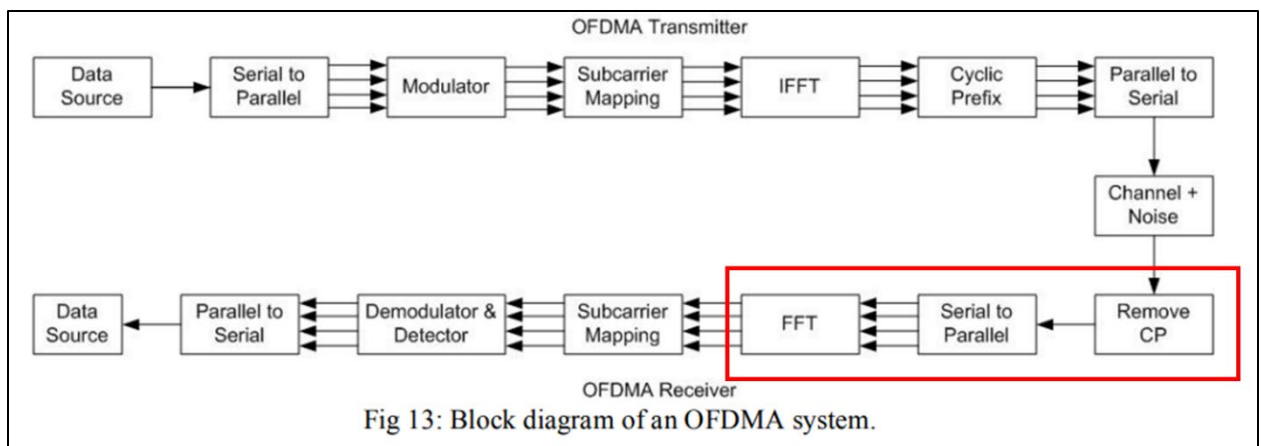
55. The accused products include a cyclic-prefix remover connected to an output of the synchronization circuit, a serial-to-parallel converter connected to an output of the cyclic prefix remover, and a discrete Fournier transform (DFT) stage connected to an output of the serial-to-parallel converter, an output of the DFT stage connected to another input to the synchronization circuit. Cyclic prefixes are added in the preamble for each transmitted frame. In a general OFDM system, a cyclic prefix remover circuit would be present at the receiver end. The output from the cyclic prefix remover circuit is fed to a serial-to-parallel converter for performing a DFT operation on its output.



(Source: <https://home.zhaw.ch/kunr/NTM1/literatur/LTE%20in%20a%20Nutshell%20-%20Physical%20Layer.pdf>)



(Source: RF Imperfections in High-rate Wireless Systems: Impact and Digital Compression, Schenk, Tim)



(Source: <http://ijettjournal.org/volume-12/number-2/IJETT-V12P214.pdf>)

56. Motorola Solutions has had actual knowledge of the '458 Patent at least as of the date when it was notified of the filing of this action. By the time of trial, Motorola Solutions will have known and intended (since receiving such notice) that its continued actions would infringe and actively induce and contribute to the infringement of one or more claims of the '458 Patent.

57. Motorola Solutions has also indirectly and willfully infringed, and continues to indirectly and willfully infringe, the ‘458 Patent, as explained further below in the “Additional Allegations Regarding Infringement” section.

58. American Patents has been damaged as a result of the infringing conduct by Motorola Solutions alleged above. Thus, Motorola Solutions is liable to American Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

59. American Patents has neither made nor sold unmarked articles that practice the ‘458 Patent, and is entitled to collect pre-filing damages for the full period allowed by law for infringement of the ‘458 Patent.

#### **COUNT IV**

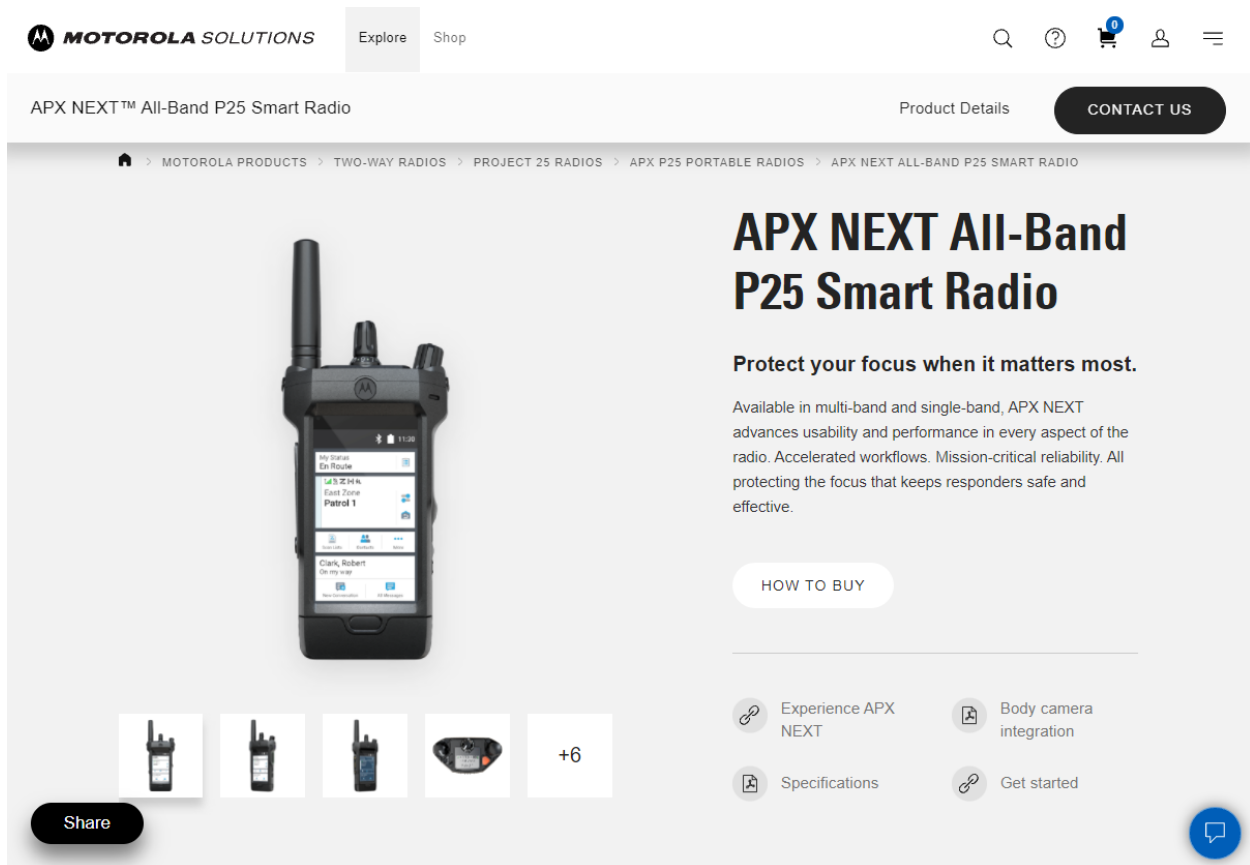
#### **INFRINGEMENT OF U.S. PATENT NO. 6,847,803**

60. On January 25, 2005, United States Patent No. 6,847,803 (“the ‘803 Patent”) was duly and legally issued by the United States Patent and Trademark Office for an invention entitled “Method for Reducing Interference in a Receiver.”

61. American Patents is the owner of the ‘803 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the ‘803 Patent against infringers, and to collect damages for all relevant times.

62. Motorola Solutions made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its Motorola Solutions APX NEXT All-Band P25 Smart Radio and Motorola Solutions LEX L11

Mission Critical LTE Device families of products, that include 802.11ac beamforming capabilities (“accused products”):



(Source: [https://www.motorolasolutions.com/en\\_us/products/two-way-radios/project-25-radios/portable-radios/apx-next.html](https://www.motorolasolutions.com/en_us/products/two-way-radios/project-25-radios/portable-radios/apx-next.html))



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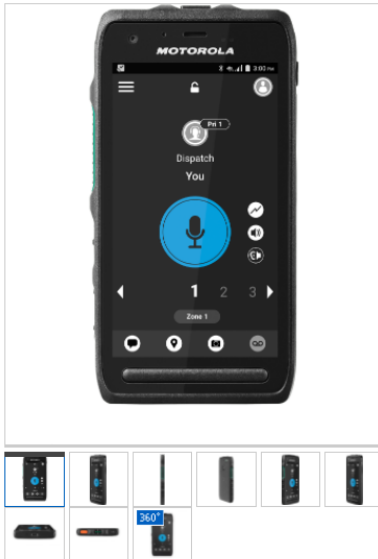
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HOME \ MOTOROLA PRODUCTS \ LTE DEVICES \ LEX L11 MISSION CRITICAL LTE DEVICE

# LEX L11 MISSION CRITICAL LTE DEVICE

## Made For The Mission Ahead



When hardware, software, and accessories work seamlessly together, the result is a device that works seamlessly for you.

The LEX L11 Mission Critical LTE Device is designed with first responders in mind. It's the result of our tireless quest to understand the way you actually work.

Every feature and function is thoughtfully considered, from the rugged, easy to operate design to the always loud and clear audio to the advanced end-to-end secure mobile platform and the enhanced accessibility provided by a suite of accessories.

Rugged and durable yet streamlined and slim, you can count on the LEX L11 to perform when it's needed most.

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[BROCHURE](#)
[LEX L11 COMPARISON TOOL](#)
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(Source: [https://www.motorolasolutions.com/en\\_us/products/lte-user-devices/lexl11.html#tabproductinfo](https://www.motorolasolutions.com/en_us/products/lte-user-devices/lexl11.html#tabproductinfo))

### WIRELESS

LTE	
Bands Supported	2, 4, 12, 13, 14
Bands (Hardware Ready)	5, 17
Device Category	4
Certifications	FirstNet®, Verizon, Bell Mobility
WiFi	
Standards Supported	802.11a/b/g/n/ac
Frequency Range	2400-2472, 5180-5825 MHz
Security	Supports WPA-2, WPA, WEP
Capacity	Up to 20 SSIDs
Bluetooth	
Version	5.0
Frequency Range	2402 - 2480 MHz
Security	128-bit AES-CCM Encryption

(Source: <https://www.motorolasolutions.com/content/dam/msi/Products/apx-next1/apx-next-data-sheet.pdf>)

Wi-Fi - Operating Band	2.4 GHz, 5 GHz
Wi-Fi - Standards	802.11 a/b/g/n/ac/k/r

(Source: [https://www.motorolasolutions.com/content/dam/msi/docs/products/lte-user-devices/lex\\_111\\_spec\\_sheet.pdf](https://www.motorolasolutions.com/content/dam/msi/docs/products/lte-user-devices/lex_111_spec_sheet.pdf))



## Wi-Fi CERTIFIED™ Certificate

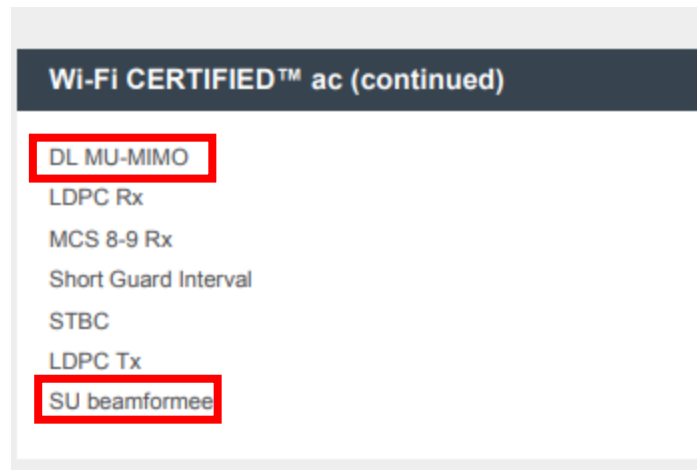
This certificate lists the features that have successfully completed Wi-Fi Alliance interoperability testing. Learn more: [www.wi-fi.org/certification/programs](http://www.wi-fi.org/certification/programs)



**Certification ID: WFA83423**

Product Info	
Date of Certification	July 16, 2019
Company	Motorola Solutions
Product Name	APX NEXT
Product Model Variant	2019-07-16 (WFA83423 - 8279666)
Model Number	APX NEXT
Category	Phones
Sub-category	Phone, multi-mode (Wi-Fi and other)

(Source: <https://api.cert.wi-fi.org/api/certificate/download/public?variantId=15277>)



(Source: <https://api.cert.wi-fi.org/api/certificate/download/public?variantId=15277>)



## Wi-Fi CERTIFIED™ Certificate

This certificate lists the features that have successfully completed Wi-Fi Alliance interoperability testing. Learn more: [www.wi-fi.org/certification/programs](http://www.wi-fi.org/certification/programs)



**Certification ID: WFA91737**

Product Info	
Date of Certification	September 12, 2019
Company	Motorola Solutions
Product Name	LEX L11
Product Model Variant	2019-09-12 (WFA91737 - 9806207)
Model Number	LEX L11
Category	Phones
Sub-category	Phone, multi-mode (Wi-Fi and other)

(Source: <https://api.cert.wi-fi.org/api/certificate/download/public?variantId=76390>)

RF Architecture		
Bands Supported	Transmit (Tx)	Receive (Rx)
2.4 GHz	2	2
5 GHz	2	2

(Source: <https://api.cert.wi-fi.org/api/certificate/download/public?variantId=76390>)

WI-FI CERTIFIED™ ac
Extended 5 GHz Channel Support
A-MPDU with A-MSDU
DL MU-MIMO
LDPC Rx
MCS 8-9 Rx
Short Guard Interval
STBC
LDPC Tx
SU beamformee

(Source: <https://api.cert.wi-fi.org/api/certificate/download/public?variantId=76390>)

## Beamforming and MU-MIMO

Beamforming is key for the support of multiuser MIMO, or [MU-MIMO](#), which is becoming more popular as 802.11ax routers roll out. As the name implies, MU-MIMO involves multiple users that can each communicate to multiple antennas on the router. MU-MIMO [uses beamforming](#) to make sure communication from the router is efficiently targeted to each connected client.

(Source: <https://www.networkworld.com/article/3445039/beamforming-explained-how-it-makes-wireless-communication-faster.html>)



63. By doing so, Motorola Solutions has directly infringed (literally and/or under the doctrine of equivalents) at least Claim 1 of the '803 Patent.

64. Motorola Solutions has infringed the '803 Patent by using the accused products and thereby practicing a method for reducing interference in a receiver for receiving information in receiving time slots, in which receiver signals are received with at least a first antenna (ANT1) and a second antenna (ANT2). For example, the accused products are and have been used by Defendant to implement the IEEE 802.11-2016 Standard, whose requirements were in effect five years before the Complaint. Devices that can communicate using 802.11 protocol are known as Stations (STAs). Multiple Input Multiple Output (MIMO) and Beamforming techniques are and have been used by a STA with multiple antennas for steering the signals to each STA ("receiver") for reception. In such MIMO transmissions, the space-time streams in the transmitted signal would be intended for reception by each STA in its corresponding time slots. These time slots at which the STA receives the space-time streams with actual data information can be construed as receiving time slots. Since, there are multiple antennas, when they transmit simultaneously, the signal appears as interference at each of the receive antennas. Further, a STA will also be able to identify the space-time streams intended for other STAs that act as interference. STA uses the channel state information that is obtained by estimating a channel to reduce the interference caused by other space time streams. The beamforming calibration procedures ("method for reducing interference") involves channel estimation and matrix calculations which help in reducing the interference in a receiver. Indeed, the IEEE 802.11-2016 Standard shows MIMO systems with two STAs (i.e., STA A and STA B) using multiple antennas ("a first antenna (ANT1) and a second antenna (ANT2)") for receiving transmitted signals.

**21.3.11.1 General**

SU-MIMO and DL-MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA. With DL-MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs.

(Source : IEEE 802.11-2016 Standard, p. 2578)

**19.3.12 Beamforming****19.3.12.1 General**

Beamforming is a technique in which the beamformer utilizes the knowledge of the MIMO channel to generate a steering matrix  $Q_k$  that improves reception in the beamformee.

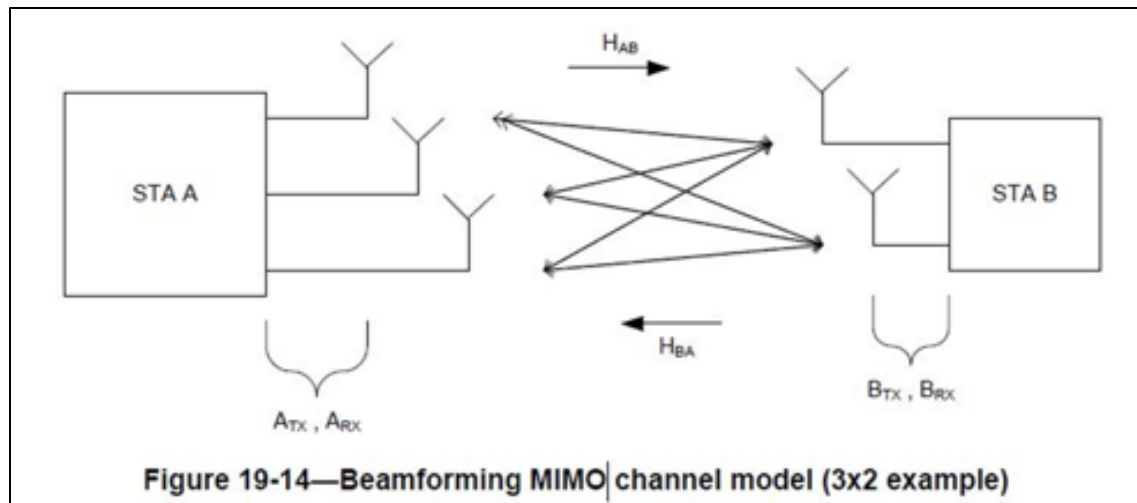
(Source : IEEE 802.11-2016 Standard, p. 2392)

A STA is also able to identify the space-time streams intended for other STAs that act as interference. VHT-LTF symbols in the VHT MU PPDU are used to measure the channel for the space-time streams intended for the STA and can also be used to measure the channel for the interfering space-time streams. To successfully demodulate the space-time streams intended for the STA, the STA may use the channel state information for all space-time streams to reduce the effect of interfering space-time streams.

(Source : IEEE 802.11-2016 Standard, p. 2580)

**(2) (STation)** A client device in an 802.11 (Wi-Fi) wireless network such as a computer, laptop or smartphone. The term STA is sometimes used for the access point (AP) as well, in which case a STA is any device communicating via the 802.11 protocol. See wireless LAN and access point.

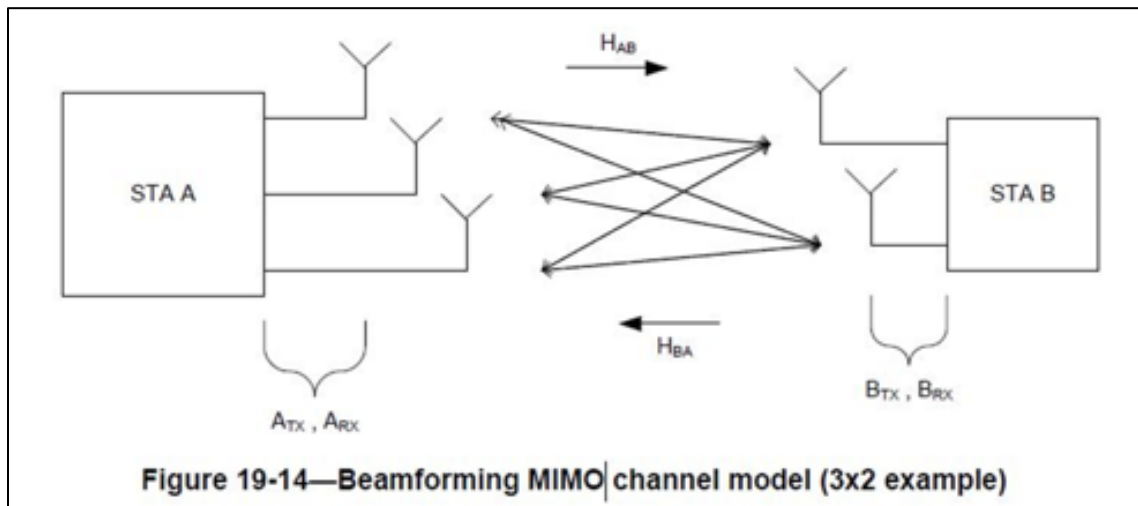
(Source : <https://www.pcmag.com/encyclopedia/term/sta>)



(Source : IEEE 802.11-2016 Standard, p. 2393)

65. The methods practiced by Motorola Solutions's use of the accused products include methods where signals are received with said first antenna (ANT1) and second antenna (ANT2) at moments of time other than in said receiving time slot, when no information is being received. For example, the accused products are and have been used by Defendant to implement the IEEE 802.11-2016 Standard, whose requirements were in effect five years before the Complaint. A STA in that Standard transmits data in PHY Protocol Data Units (PPDUs). PPDUs can be transmitted in High Throughput (HT) mode and Very High Throughput (VHT) mode. A Null Data Packet (NDP) can be transmitted in both HT and VHT Modes. Training Fields (TFs) inside the NDP carry no data related information and can be used as sounding PPDUs in beamforming calibration procedures. Sounding PPDUs would help in channel estimation at the STA. Certain TFs include the interference information which is used as reference during calibration procedures. The NDPs ("signals received") in HT-PPDU and VHT PPDU format includes several TFs which are and have been used as a reference for the receiver to perform calibration/tuning. Thus, there is no actual data information that is received during the

beamforming calibration procedures (“at moments of time other than in said receiving time slots”).



(Source : IEEE 802.11-2016 Standard, p. 2393)

Table 19-5—Elements of the HT PPDU	
Element	Description
L-STF	Non-HT Short Training field
L-LTF	Non-HT Long Training field
L-SIG	Non-HT SIGNAL field
HT-SIG	HT SIGNAL field
HT-STF	HT Short Training field
HT-GF-STF	HT-Greenfield Short Training field
HT-LTF1	First HT Long Training field (Data)
HT-LTFs	Additional HT Long Training fields (Data and Extension)
Data	The Data field includes the PSDU

(Source : IEEE 802.11-2016 Standard, p. 2347)

**Table 21-4—Fields of the VHT PPDU**

Field	Description
L-STF	Non-HT Short Training field
L-LTF	Non-HT Long Training field
L-SIG	Non-HT SIGNAL field
VHT-SIG-A	VHT Signal A field
VHT-STF	VHT Short Training field
VHT-LTF	VHT Long Training field
VHT-SIG-B	VHT Signal B field
Data	The Data field carrying the PSDU(s)

The VHT-SIG-A, VHT-STF, VHT-LTF, and VHT-SIG-B fields exist only in VHT PPDU. In a VHT NDP the Data field is not present. The number of symbols in the VHT-LTF field,  $N_{VHTLTF}$ , can be either 1, 2, 4, 6, or 8 and is determined by the total number of space-time streams across all users being transmitted in the VHT PPDU (see Table 21-13).

(Source : IEEE 802.11-2016 Standard, p. 2514)

In both HT-mixed format and HT-greenfield format frames, there are two types of HT-LTFs: Data HT-LTFs (HT-DLTFs) and Extension HT-LTFs (HT-ELTFs). HT-DLTFs are always included in HT PPDU to provide the necessary reference for the receiver to form a channel estimate that allows it to demodulate the data

(Source : IEEE 802.11-2016 Standard, p. 2347)

**null data packet (NDP):** A physical layer (PHY) protocol data unit (PPDU) that carries no Data field.

**off-channel:** A channel used by a tunneled direct link setup (TDLS) station (STA) that does not overlap the channel(s) used by the access point (AP) with which the TDLS STA is associated.

(Source : IEEE 802.11-2016 Standard, p. 157)

**sounding physical layer (PHY) protocol data unit (PPDU):** A PPDU that is intended by the transmitting station (STA) to enable the receiving STA to estimate the channel between the transmitting STA and the receiving STA. The Not Sounding field in the High Throughput SIGNAL field (HT-SIG) is equal to 0 in sounding PPDU.

(Source : IEEE 802.11-2016 Standard, p. 163)

**21.3.12 VHT preamble format for sounding PPDU**

NDP is the only VHT sounding format.

The format of a VHT NDP PPDU is shown in Figure 21-28.



**Figure 21-28—VHT NDP format**

NOTE—The number of VHT-LTF symbols in the NDP is determined by the SU NSTS field in VHT-SIG-A.

The VHT NDP PPDU has the following properties:

- Uses the VHT PPDU format but without the Data field.
- Is a VHT SU PPDU as indicated by the VHT-SIG-A field.
- Has the data bits of the VHT-SIG-B field set to a fixed bit pattern (see 21.3.8.3.6).

(Source : IEEE 802.11-2016 Standard, p. 2580)

**10.34 Null data packet (NDP) sounding****10.34.1 HT NDP sounding protocol**

Sounding may be accomplished using either staggered sounding PPDU or HT NDP, as described in 19.3.13. The MAC rules associated with sounding using HT NDP are described in 10.34.1 to 10.34.4.

(Source : IEEE 802.11-2016 Standard, p. 1485)

66. The methods practiced by Motorola Solutions's use of the accused products include methods in which a reference signal representing interference in said other time slot is formed and used for the tuning of the receiver in said receiving time slots. For example, the accused products are and have been used by Defendant to implement the IEEE 802.11-2016 Standard, whose requirements were in effect five years before the Complaint. In that Standard, beamforming techniques are and have been used to improve the reception at a receiver STA. These techniques use the channel state information and generate steering matrices for the transmission of data. There are two types of beamforming methods described in the standard, Implicit feedback beamforming and Explicit feedback beamforming. A steering matrix,  $Q_k$ , is

calculated in both beamforming methods. Explicit feedback beamforming enables a beamformee i.e., receiving STA to calculate beamforming feedback matrix based on the received sounding packets/PPDUs. NDPs can be used as sounding PPDUs and hence, no data/information is received during the beamforming procedures. The Standard shows a scenario wherein STA A (transmit STA) transmits a sounding packet (which can be NDP PDU) that is used by STA B (receiving STA) to calculate a beamforming feedback matrix  $V_k$  ("reference signal"). The feedback matrix is later sent to STA A for determining a steering matrix which is used to tune and re-calibrate the receiver STA in order to demodulate the transmitted signal. Implicit feedback beamforming enables STA to estimate a MIMO channel and calculate channel matrices, based on a received sounding PDU. NDPs can be used as sounding PPDUs and hence, no data/information is received during the beamforming procedures. The Standard shows a scenario wherein STA A and STA B (receiving STA) follow beamforming calibration procedures using sounding PPDUs. STA A and STA B will exchange sounding PPDUs (which can be NDP PPDUs), using which each of the STAs will estimate respective channel matrices. Quantized estimates of the channel matrices ("reference signal") are sent from STA B to STA A. Later, STA A uses its local estimates and the received quantized estimates from STA B to calculate set of correction matrices. These correction matrices that are formed using the received quantized estimates, are applied at transmit side of a STA to correct/tune the amplitude and phase differences in transmit and receive chains. All the above discussed steps are performed as a part of beamforming calibration procedures using sounding PPDUs. The Standard also shows equations for the received signal with beamforming. The channel estimates and beamforming steering matrix are and have been used to tune and re-calibrate the receiver in order to demodulate the transmitted signal.



### 19.3.12 Beamforming

#### 19.3.12.1 General

Beamforming is a technique in which the beamformer utilizes the knowledge of the MIMO channel to generate a steering matrix  $Q_k$  that improves reception in the beamformee.

The equivalent complex baseband MIMO channel model is one in which, when a vector  $\mathbf{x}_k = [x_1, x_2, \dots, x_{N_{TX}}]^T$  is transmitted in subcarrier  $k$ , the received vector  $\mathbf{y}_k = [y_1, y_2, \dots, y_{N_{RX}}]^T$  is modeled as shown in Equation (19-62).

$$\mathbf{y}_k = H_k \mathbf{x}_k + \mathbf{n} \quad (19-62)$$

where

$H_k$  is channel matrix of dimensions  $N_{RX} \times N_{TX}$

$\mathbf{n}$  is white (spatially and temporally) Gaussian noise as illustrated in Figure 19-14

(Source : IEEE 802.11-2016 Standard, p. 2392-2393)

When beamforming is used, the beamformer replaces  $\mathbf{x}_k$ , which in this case has  $N_{STS} \leq N_{TX}$  elements, with  $Q_k \mathbf{x}_k$ , where  $Q_k$  has  $N_{TX}$  rows and  $N_{STS}$  columns, so that the received vector is as shown in Equation (19-63).

$$\mathbf{y}_k = H_k Q_k \mathbf{x}_k + \mathbf{n} \quad (19-63)$$

The beamforming steering matrix that is computed (or updated) from a new channel measurement replaces the existing  $Q_k$  for the next beamformed data transmission. There are several methods of beamforming, differing in the way the beamformer acquires the knowledge of the channel matrices  $H_k$  and on whether the beamformer generates  $Q_k$  or the beamformee provides feedback information for the beamformer to generate  $Q_k$ .

(Source : IEEE 802.11-2016 Standard, p. 2393)



### 19.3.12.3 Explicit feedback beamforming

#### 19.3.12.3.1 General

In explicit beamforming, in order for STA A to transmit a beamformed packet to STA B, STA B measures the channel matrices and sends STA A either the effective channel,  $H_{eff,k}$ , or the beamforming feedback matrix,  $V_k$ , for STA A to determine a steering matrix,  $Q_{steer,k} = Q_k V_k$ , with  $V_k$  found from  $H_k Q_k$ , where  $Q_k$  is the orthonormal spatial mapping matrix that was used to transmit the sounding packet that elicited the  $V_k$  feedback. The effective channel,  $H_{eff,k} = H_k Q_k$ , is the product of the spatial mapping matrix used on transmit with the channel matrix. When new steering matrix  $Q_{steer,k}$  is found,  $Q_{steer,k}$  may replace  $Q_k$  for the next beamformed data transmission.

NOTE— $Q_{steer,k}$  is a mathematical term to update a new steering matrix for  $Q_k$  in the next beamformed data transmission.

(Source : IEEE 802.11-2016 Standard, p. 1477)

### 10.32.3 Explicit feedback beamforming

The procedures in this subclause apply only to HT and non-HT PPDU for which the HT Control field, if present, is the HT variant HT Control field.

In this subclause, the terms *HT beamformer* and *HT beamformee* refer to STAs that are involved in explicit feedback beamforming.

An HT beamformer uses the feedback response that it receives from the HT beamformee to calculate a beamforming feedback matrix for transmit beamforming. This feedback response may have one of three formats:

- *CSI*: The HT beamformee sends the MIMO channel coefficients to the HT beamformer.
- *Noncompressed beamforming*: The HT beamformee sends calculated beamforming feedback matrices to the HT beamformer.
- *Compressed beamforming*: The HT beamformee sends compressed beamforming feedback matrices to the HT beamformer.

(Source : IEEE 802.11-2016 Standard, p. 1477)

### 10.34 Null data packet (NDP) sounding

#### 10.34.1 HT NDP sounding protocol

Sounding may be accomplished using either staggered sounding PPDU or HT NDP, as described in 19.3.13. The MAC rules associated with sounding using HT NDP are described in 10.34.1 to 10.34.4.

(Source : IEEE 802.11-2016 Standard, p. 1477)

### 10.34.5 VHT sounding protocol

#### 10.34.5.1 General

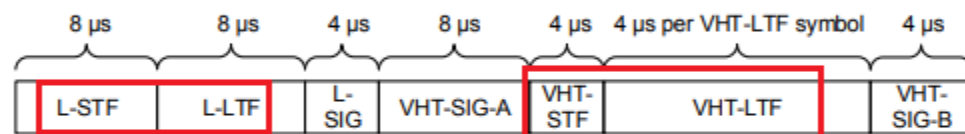
Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the *VHT beamformer*, and a STA for which reception is optimized is called a *VHT beamformee*. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.

(Source : IEEE 802.11-2016 Standard, p. 1477)

#### 21.3.12 VHT preamble format for sounding PPDU

NDP is the only VHT sounding format.

The format of a VHT NDP PPDU is shown in Figure 21-28.



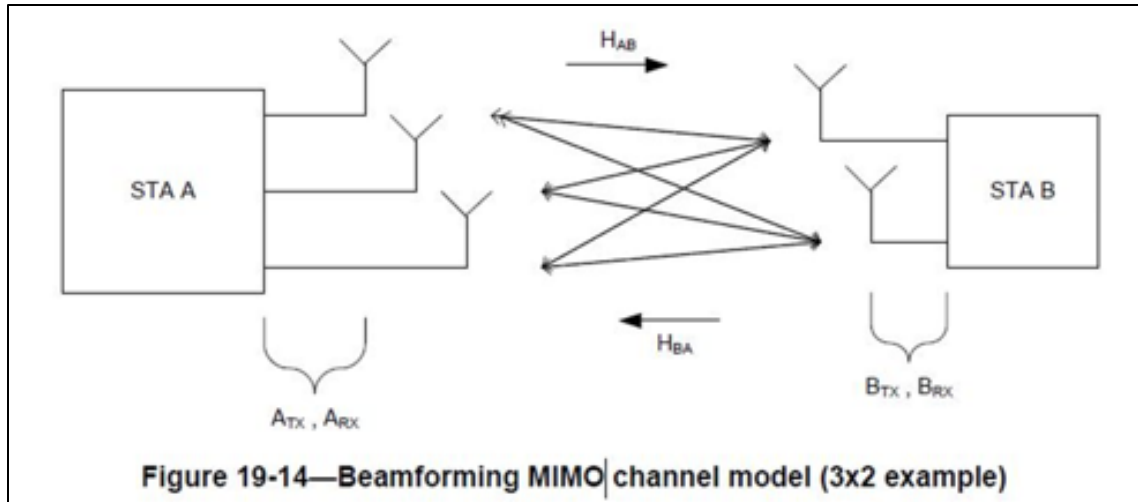
**Figure 21-28—VHT NDP format**

NOTE—The number of VHT-LTF symbols in the NDP is determined by the SU NSTS field in VHT-SIG-A.

The VHT NDP PPDU has the following properties:

- Uses the VHT PPDU format but without the Data field.
- Is a VHT SU PPDU as indicated by the VHT-SIG-A field.
- Has the data bits of the VHT-SIG-B field set to a fixed bit pattern (see 21.3.8.3.6).

(Source : IEEE 802.11-2016 Standard, p. 2580)

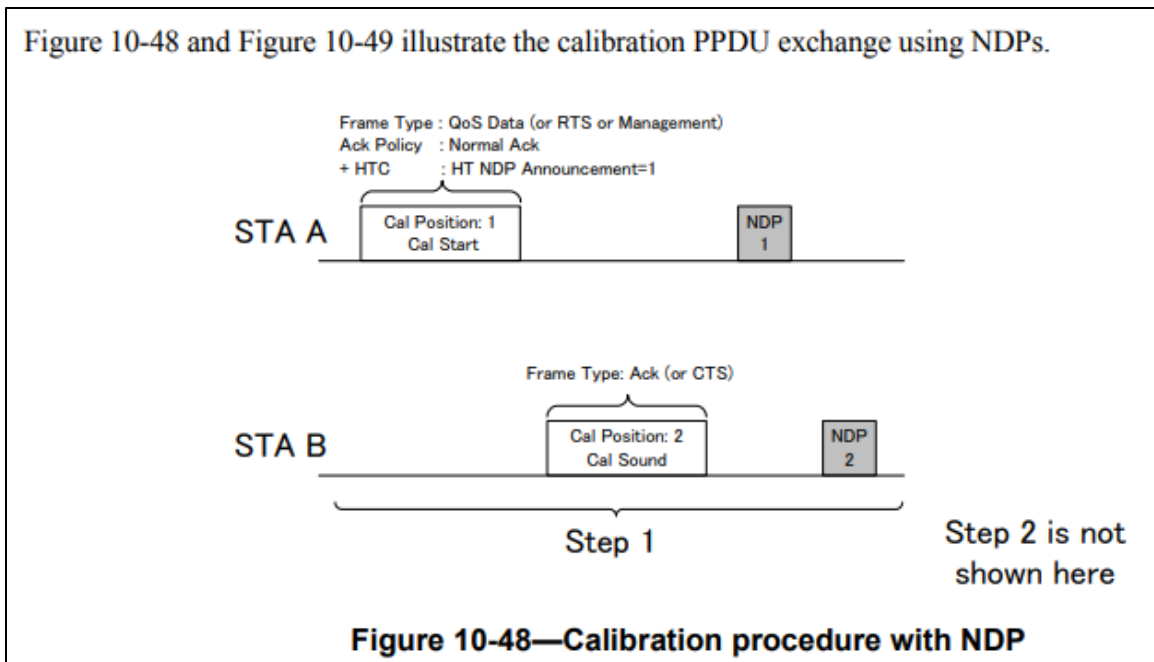


(Source : IEEE 802.11-2016 Standard, p. 2393)

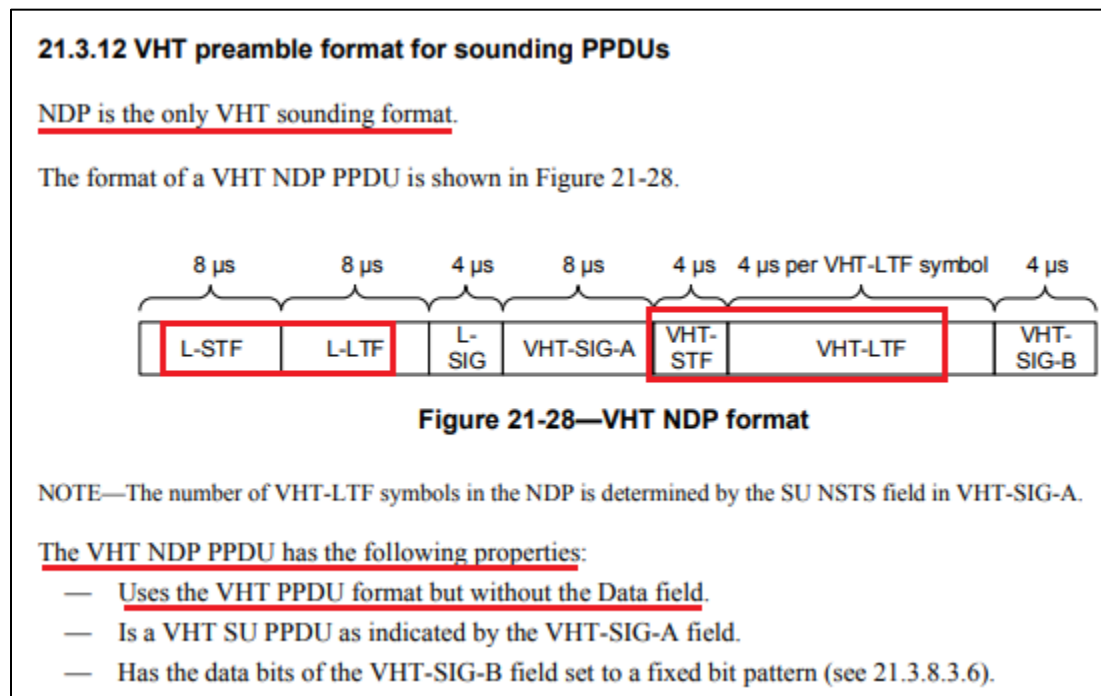
Focusing on STA A, the procedure for estimating  $K_{A,k}$  is as follows:

- a) STA A sends STA B a sounding PPDU, the reception of which allows STA B to estimate the channel matrices  $\tilde{H}_{AB,k}$ .
- b) STA B sends STA A a sounding PPDU, the reception of which allows STA A to estimate the channel matrices  $\tilde{H}_{BA,k}$ .
- c) STA B sends the quantized estimates of  $\tilde{H}_{AB,k}$  to STA A.
- d) STA A uses its local estimates of  $\tilde{H}_{BA,k}$  and the quantized estimates of  $\tilde{H}_{AB,k}$  received from STA B to compute the correction matrices  $K_{A,k}$ .

(Source : IEEE 802.11-2016 Standard, p. 2395)



(Source : IEEE 802.11-2016 Standard, p. 1475)



(Source : IEEE 802.11-2016 Standard, p. 2580)

While the over-the-air channel between the antenna(s) at one STA and the antenna(s) at a second STA is reciprocal, the observed baseband-to-baseband channel used for communication might not be, as it includes the transmit and receive chains of the STAs. Differences in the amplitude and phase characteristics of the transmit and receive chains associated with individual antennas degrade the reciprocity of the over-the-air channel and cause degradation of performance of implicit beamforming techniques. The over-the-air calibration procedure described in 10.32.2.4 may be used to restore reciprocity. The procedure provides the means for calculating a set of correction matrices that can be applied at the transmit side of a STA to correct the amplitude and phase differences between the transmit and receive chains in the STA. If this correction is done at least at the STA that serves as the beamformer, there is sufficient reciprocity for implicit feedback in the baseband-to-baseband response of the forward link and reverse channel.

(Source : IEEE 802.11-2016 Standard, p. 2394)

### **19.3.13.3 Sounding PPDU for calibration**

In the case of a bidirectional calibration exchange, two STAs exchange sounding PPDU, the exchange of which enables the receiving STA to compute an estimate of the MIMO channel matrix  $H_k$  for each subcarrier  $k$ . In general, in an exchange of calibration messages, the number of spatial streams is less than the number of transmit antennas. In such cases, HT-ELTFs are used. In the case of sounding PPDU for calibration, the antenna mapping matrix shall be as shown in Equation (19-86).

(Source : IEEE 802.11-2016 Standard, p. 2401)

Two preamble formats are defined. For HT-mixed format operation, the preamble has a non-HT portion and an HT portion. The non-HT portion of the HT-mixed format preamble enables detection of the PPDU and acquisition of carrier frequency and timing by both HT STAs and STAs that are compliant with Clause 17 and/or Clause 18. The non-HT portion of the HT-mixed format preamble also consists of the SIGNAL field defined in Clause 17 and is thus decodable by STAs compliant with Clause 17 and Clause 18 as well as HT STAs.

The HT portion of the HT-mixed format preamble enables estimation of the MIMO channel to support demodulation of the HT data by HT STAs. The HT portion of the HT-mixed format preamble also includes the HT-SIG field, which supports HT operation. The SERVICE field is prepended to the PSDU.

(Source : IEEE 802.11-2016 Standard, p. 2346)



### 19.3.12 Beamforming

#### 19.3.12.1 General

Beamforming is a technique in which the beamformer utilizes the knowledge of the MIMO channel to generate a steering matrix  $\mathbf{Q}_k$  that improves reception in the beamformee.

The equivalent complex baseband MIMO channel model is one in which, when a vector  $\mathbf{x}_k = [x_1, x_2, \dots, x_{N_{TX}}]^T$  is transmitted in subcarrier  $k$ , the received vector  $\mathbf{y}_k = [y_1, y_2, \dots, y_{N_{RX}}]^T$  is modeled as shown in Equation (19-62).

$$\mathbf{y}_k = \mathbf{H}_k \mathbf{x}_k + \mathbf{n} \quad (19-62)$$

where

$\mathbf{H}_k$  is channel matrix of dimensions  $N_{RX} \times N_{TX}$

$\mathbf{n}$  is white (spatially and temporally) Gaussian noise as illustrated in Figure 19-14

(Source : IEEE 802.11-2016 Standard, p. 2392-2393)

When beamforming is used, the beamformer replaces  $\mathbf{x}_k$ , which in this case has  $N_{STS} \leq N_{TX}$  elements, with  $\mathbf{Q}_k \mathbf{x}_k$ , where  $\mathbf{Q}_k$  has  $N_{TX}$  rows and  $N_{STS}$  columns, so that the received vector is as shown in Equation (19-63).

$$\mathbf{y}_k = \mathbf{H}_k \mathbf{Q}_k \mathbf{x}_k + \mathbf{n} \quad (19-63)$$

The beamforming steering matrix that is computed (or updated) from a new channel measurement replaces the existing  $\mathbf{Q}_k$  for the next beamformed data transmission. There are several methods of beamforming, differing in the way the beamformer acquires the knowledge of the channel matrices  $\mathbf{H}_k$  and on whether the beamformer generates  $\mathbf{Q}_k$  or the beamformee provides feedback information for the beamformer to generate  $\mathbf{Q}_k$ .

(Source : IEEE 802.11-2016 Standard, p. 2393)

67. American Patents only asserts method claims from the '803 Patent.

68. American Patents has been damaged as a result of the infringing conduct by Motorola Solutions alleged above. Thus, Motorola Solutions is liable to American Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less

than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

**ADDITIONAL ALLEGATIONS REGARDING INFRINGEMENT**

69. In addition to any specific products mentioned above, the accused products also include at least Motorola Solutions APX8000HXE Model 3.5, Motorola Solutions APX8000HXE Model 2.5, Motorola Solutions APX8000HXE Model 1.5, Motorola Solutions APX NEXT, Motorola Solutions APX NEXT XE, Motorola Solutions MOTOTRBO ION, Motorola Solutions MOTOTRBO XPR 7000e, Motorola Solutions Nitro Evolve, Motorola Solutions LEX L11, Motorola Solutions SLX 2000, Motorola Solutions SLX 4000, Motorola Solutions TLK 150, Motorola Solutions LXN 6000, Motorola Solutions LXN 505, Motorola Solutions VB400, Motorola Solutions VT100, and Motorola Solutions VLP Comms Box.

70. Motorola Solutions has also indirectly infringed the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent by inducing others to directly infringe the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent. Motorola Solutions has induced the end-users, Motorola Solutions’s customers, to directly infringe (literally and/or under the doctrine of equivalents) the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent by using the accused products.

71. Motorola Solutions took active steps, directly and/or through contractual relationships with others, with the specific intent to cause them to use the accused products in a manner that infringes one or more claims of the patents-in-suit, including, for example, Claim 30 of the ‘782 Patent, Claim 1 of the ‘304 Patent, and Claim 1 of the ‘458 Patent.

72. Such steps by Motorola Solutions included, among other things, advising or directing customers and end-users to use the accused products in an infringing manner;

advertising and promoting the use of the accused products in an infringing manner; and/or distributing instructions that guide users to use the accused products in an infringing manner.

73. Motorola Solutions has performed these steps, which constitute induced infringement, with the knowledge of the '782 Patent, the '304 Patent, and the '458 Patent and with the knowledge that the induced acts constitute infringement.

74. Motorola Solutions was and is aware that the normal and customary use of the accused products by Motorola Solutions's customers would infringe the '782 Patent, the '304 Patent, and the '458 Patent. Motorola Solutions's inducement is ongoing.

75. Motorola Solutions has also induced its affiliates, or third-party manufacturers, shippers, distributors, retailers, or other persons acting on its or its affiliates' behalf, to directly infringe (literally and/or under the doctrine of equivalents) the '782 Patent, the '304 Patent, and the '458 Patent by importing, selling, offering to sell, and/or using the accused products.

76. Motorola Solutions has at least a significant role in placing the accused products in the stream of commerce in Texas and elsewhere in the United States.

77. Motorola Solutions directs or controls the making of accused products and their shipment to the United States, using established distribution channels, for sale in Texas and elsewhere within the United States.

78. Motorola Solutions directs or controls the sale of the accused products into established United States distribution channels, including sales to nationwide retailers.

79. Motorola Solutions's established United States distribution channels include one or more United States based affiliates (e.g., at least Motorola Solutions Video Manufacturing, Inc.).



80. Motorola Solutions directs or controls the sale of the accused products nationwide through its own websites, including for sale in Texas and elsewhere in the United States, and expects and intends that the accused products will be so sold.

81. Motorola Solutions took active steps, directly and/or through contractual relationships with others, with the specific intent to cause such persons to import, sell, or offer to sell the accused products in a manner that infringes one or more claims of the patents-in-suit, including, for example, Claim 30 of the '782 Patent, Claim 1 of the '304 Patent, and Claim 1 of the '458 Patent.

82. Such steps by Motorola Solutions included, among other things, making or selling the accused products outside of the United States for importation into or sale in the United States, or knowing that such importation or sale would occur; and directing, facilitating, or influencing its affiliates, or third-party manufacturers, shippers, distributors, retailers, or other persons acting on its or their behalf, to import, sell, or offer to sell the accused products in an infringing manner.

83. Motorola Solutions performed these steps, which constitute induced infringement, with the knowledge of the '782 Patent, the '304 Patent, and the '458 Patent and with the knowledge that the induced acts would constitute infringement.

84. Motorola Solutions performed such steps in order to profit from the eventual sale of the accused products in the United States.

85. Motorola Solutions's inducement is ongoing.

86. Motorola Solutions has also indirectly infringed by contributing to the infringement of the '782 Patent, the '304 Patent, and the '458 Patent. Motorola Solutions has

contributed to the direct infringement of the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent by the end-user of the accused products.

87. The accused products have special features that are specially designed to be used in an infringing way and that have no substantial uses other than ones that infringe the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent, including, for example, Claim 30 of the ‘782 Patent, Claim 1 of the ‘304 Patent, and Claim 1 of the ‘458 Patent.

88. As described above, the special features include improved wireless communication capabilities used in a manner that infringes the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent.

89. The special features constitute a material part of the invention of one or more of the claims of the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent and are not staple articles of commerce suitable for substantial non-infringing use.

90. Motorola Solutions’s contributory infringement is ongoing.

91. Furthermore, Motorola Solutions has a policy or practice of not reviewing the patents of others (including instructing its employees to not review the patents of others), and thus has been willfully blind of American Patents’ patent rights. *See, e.g.*, M. Lemley, “Ignoring Patents,” 2008 Mich. St. L. Rev. 19 (2008).

92. Motorola Solutions’s actions are at least objectively reckless as to the risk of infringing valid patents and this objective risk was either known or should have been known by Motorola Solutions.

93. Motorola Solutions has knowledge of the ‘782 Patent, the ‘304 Patent, and the ‘458 Patent.

94. Motorola Solutions's customers have infringed the '782 Patent, the '304 Patent, and the '458 Patent.

95. Motorola Solutions encouraged its customers' infringement.

96. Motorola Solutions's direct and indirect infringement of the '782 Patent, the '304 Patent, and the '458 Patent is, has been, and/or continues to be willful, intentional, deliberate, and/or in conscious disregard of American Patents' rights under the patents.

97. American Patents has been damaged as a result of the infringing conduct by Motorola Solutions alleged above. Thus, Motorola Solutions is liable to American Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

#### **JURY DEMAND**

American Patents hereby requests a trial by jury on all issues so triable by right.

#### **PRAYER FOR RELIEF**

American Patents requests that the Court find in its favor and against Motorola Solutions, and that the Court grant American Patents the following relief:

a. Judgment that one or more claims of the '782 Patent, the '304 Patent, the '458 Patent, and the '803 Patent have been infringed, either literally and/or under the doctrine of equivalents, by Motorola Solutions and/or all others acting in concert therewith;

b. A permanent injunction enjoining Motorola Solutions and its officers, directors, agents, servants, affiliates, employees, divisions, branches, subsidiaries, parents, and all others acting in concert therewith from infringement of the '782 Patent, the '304 Patent, and the '458 Patent; or, in the alternative, an award of a reasonable ongoing royalty for future infringement of

the '782 Patent, the '304 Patent, and the '458 Patent by such entities;

c. Judgment that Motorola Solutions account for and pay to American Patents all damages to and costs incurred by American Patents because of Motorola Solutions's infringing activities and other conduct complained of herein, including an award of all increased damages to which American Patents is entitled under 35 U.S.C. § 284;

d. That American Patents be granted pre-judgment and post-judgment interest on the damages caused by Motorola Solutions's infringing activities and other conduct complained of herein;

e. That this Court declare this an exceptional case and award American Patents its reasonable attorney's fees and costs in accordance with 35 U.S.C. § 285; and

f. That American Patents be granted such other and further relief as the Court may deem just and proper under the circumstances.

Dated: October 25, 2021

Respectfully submitted,

/s/ Zachariah S. Harrington

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